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Smart Greenhouse and Monitoring Control System

Prof. S. P. Gopnaryan[1], Rutuja Dornal[2], Bhakti Gaikwad[3], Sakshi Jaybhaye[4], Pranali Pawar[5]
Department of Electronics and Telecommunication Engineering, AISSMS Polytechnic, Pune, India

Abstract: ***The Smart Greenhouse Monitoring and Control System is an automated system designed to monitor and maintain suitable environmental conditions for plant growth inside a greenhouse. In traditional greenhouse farming, farmers have to manually check factors like temperature, humidity, soil moisture, and light, which requires a lot of time and effort. This system uses sensors such as the DHT11 sensor to measure temperature and humidity, a soil moisture sensor to check the water level in the soil, and an LDR sensor to detect light intensity. These sensors collect real-time data and send it to the Arduino microcontroller. The Arduino processes the data and compares it with preset values. If any condition goes beyond the required level, the system automatically activates devices like water pumps for irrigation, exhaust fans for cooling, and lights for proper illumination. The system can also be connected with IoT technology, allowing users to monitor greenhouse conditions remotely using a mobile phone or computer. This automation reduces manual work, saves water and energy, and helps improve crop growth and productivity. Overall, the Smart Greenhouse system shows how modern technology can support efficient and sustainable agriculture.***

I. INTRODUCTION

Agriculture is one of the most important sectors for the economic growth of many countries. With the increasing population, the demand for good quality agricultural products is also rising. However, traditional farming mainly depends on natural weather conditions and manual monitoring, which can sometimes lead to inconsistent crop production, water wastage, and higher labor efforts. Because of these challenges, modern agriculture is gradually adopting automation and smart farming technologies.

A greenhouse is a structure that helps protect plants from unfavorable weather and provides a controlled environment for better crop growth. Even though greenhouses offer better control than open farming, it is still necessary to regularly monitor factors such as temperature, humidity, soil moisture, and light intensity. If these conditions are not properly maintained, plant growth can be affected and crop production may decrease.

The Smart Greenhouse Monitoring and Control System is designed to solve these problems by using automation. In this system, different sensors monitor the environmental conditions inside the greenhouse. A microcontroller receives the sensor data and automatically controls devices such as water pumps, ventilation fans, and lights based on preset values. This helps maintain the ideal conditions needed for healthy plant growth.

In addition, the system can be connected with IoT technology, which allows farmers to monitor greenhouse conditions remotely through a mobile phone or computer. They can view real-time data, receive alerts, and manage the greenhouse easily from anywhere. This system helps improve crop quality and productivity while reducing water usage, labor, and operational costs, making farming more efficient and sustainable.

II. LITERATURE SURVEY

With the development of automation and Internet of Things (IoT) technology, agriculture is gradually moving toward smart farming methods. These technologies help farmers monitor crops easily and use resources like water and energy more efficiently. Many researchers have developed automated greenhouse systems that monitor environmental conditions and control them automatically to improve plant growth. Earlier greenhouse systems mainly depended on manual monitoring, where farmers had to check temperature, humidity, and soil moisture and adjust irrigation or ventilation themselves. This method required more time and effort and sometimes caused errors that could affect crop quality and yield. In recent years, microcontrollers such as Arduino and NodeMCU have been used to develop automated greenhouse systems. These systems use sensors to collect environmental data and automatically control devices like fans, water pumps, and lights through relay modules. This helps maintain proper conditions while saving water and energy. Many modern systems also include IoT technology, which allows farmers to monitor greenhouse conditions remotely using mobile applications or web dashboards. Overall, combining sensors, microcontrollers, and IoT provides an efficient and practical solution for smart greenhouse management.

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III. PROBLEM STATEMENT

Traditional farming relies heavily on manual monitoring and natural conditions, which makes greenhouse management time-consuming and prone to errors. Factors like temperature, humidity, soil moisture, and air quality must be kept within proper limits for healthy plant growth, but manual control can lead to poor crop growth, water wastage, and lower productivity. Farmers also cannot always be present to check the greenhouse, so delayed responses to environmental changes are common. This creates a need for a smart, automated system that can continuously monitor conditions and automatically maintain the ideal environment for plants.

IV. PROPOSED METHODOLOGY

The Smart Greenhouse Monitoring and Control System uses sensors, a microcontroller, relay modules, and IoT technology to automate greenhouse management. It includes a DHT11 sensor for temperature and humidity, a soil moisture sensor, and an MQ-2 gas sensor for detecting harmful gases. These sensors continuously collect data and send it to the Arduino UNO. The Arduino compares the data with preset limits and automatically controls devices through relay modules. For example, it turns on the water pump when soil is dry, starts a fan when temperature rises, or activates an exhaust fan if harmful gases are detected. The system also uses an ESP8266 WiFi module to upload sensor data to a cloud platform. This allows farmers to monitor greenhouse conditions remotely via a smartphone or computer. Overall, the system ensures automatic control, continuous monitoring, and efficient resource management.

V. COMPONENTS USED

1) *DHT11 Sensor:* is used in the smart greenhouse to measure temperature and humidity. It detects changes in the surrounding environment and sends the data to the Arduino microcontroller. The Arduino reads this data and compares it with preset values. If the temperature or humidity goes beyond the required level, the system automatically controls devices such as fans or irrigation systems. This helps maintain a suitable environment for healthy plant growth inside the greenhouse.

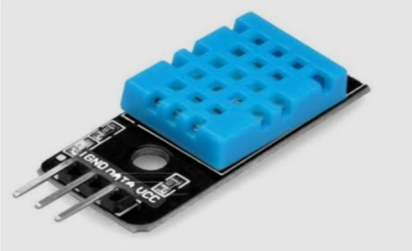

Fig : DHT11 Sensor

2) *Soil Moisture Sensor:* The soil moisture sensor measures how much water is in the soil using two probes. It works on electrical conductivity wet soil has low resistance, and dry soil has high resistance. The sensor sends this information to the Arduino, which checks the soil moisture level. If the soil is too dry, the Arduino turns on the water pump through a relay to water the plants. Once the soil reaches the right moisture level, the pump turns off automatically, ensuring proper irrigation and saving water.

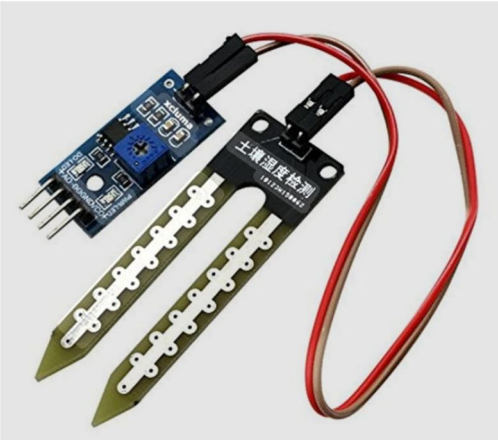

Fig : Soil Moisture Sensor

3) *The MQ-2 gas Sensor:* detects harmful gases in the smart greenhouse, including LPG, methane, hydrogen, and smoke. It uses a tin dioxide (SnO_2) sensing layer. The sensor's resistance changes when it encounters gases. This change generates an analog signal that the Arduino receives. If the gas level goes beyond the safe limit, the Arduino turns on an exhaust fan with a relay to clear out the polluted air. The system can also send alerts through a WiFi module, which helps keep the greenhouse environment safe.

Fig. 3 MQ-2 Gas/Smoke Sensor

4) *ESP8266 WiFi Module:* offers wireless connectivity and enables IoT features in the smart greenhouse system. It connects the system to a WiFi network and sends sensor data from the Arduino to a cloud platform via serial communication. This lets users monitor greenhouse conditions in real time using a smartphone or computer. The module also supports remote control and data logging, helping farmers track environmental conditions and manage the greenhouse more effectively.

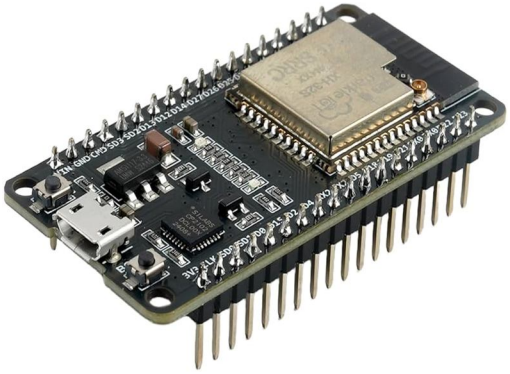

Fig. ESP 32 Microcontroller

5) *Relay Module:* The relay module connects the low-voltage Arduino to high-voltage devices like water pumps and fans. It operates based on electromagnetic switching. When the Arduino sends a signal, the relay coil generates a magnetic field that changes the internal contacts, turning the connected device ON or OFF. The relay also offers electrical isolation, which protects the Arduino from high voltage. In the smart greenhouse system, it helps safely control devices such as irrigation pumps, ventilation fans, and lighting automatically.

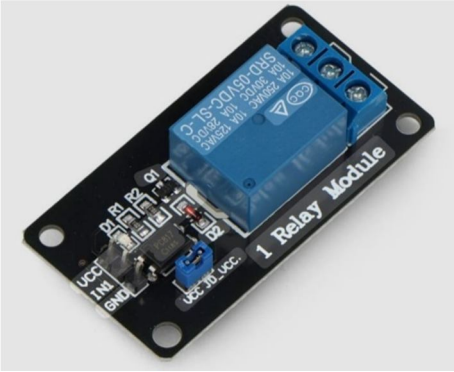

Fig : Relay Module.

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6) *Arduino Nano:* The Arduino Nano is the main controller of the smart greenhouse system. It gathers data from sensors like the DHT11 for temperature and humidity, the soil moisture sensor, and the MQ-2 gas sensor. The Arduino compares these sensor readings to preset limits and controls devices through a relay module. For instance, it turns on the fan when the temperature is high, activates the water pump when the soil moisture is low, and starts the exhaust fan if it detects harmful gases. It also connects to the ESP8266 WiFi module to send data to the cloud, enabling remote monitoring and control of the greenhouse.

Fig : Ardiuno Nnao

7) *Ardiuno UNO:* The Arduino UNO is a microcontroller board that acts as the primary controller for the smart greenhouse system. It is based on the ATmega328P microcontroller. It has some digital and analog input/output pins for connecting various devices. Arduino UNO reads data from various sensors such as the DHT11 temperature sensor, soil moisture sensor, and MQ2 gas sensor. Then, it processes this data and controls various devices such as fans, water pumps, and lights using relay modules. It is also able to connect to the ESP8266 WiFi module for data transmission to the cloud.

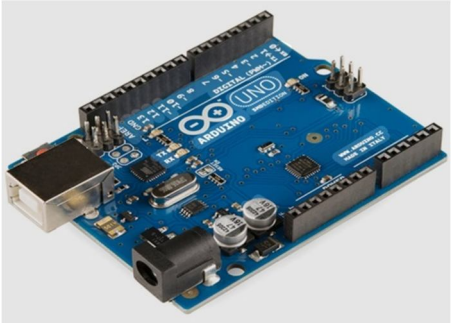


Fig : Ardiuno UNO

8) *OLED Display:* An OLED display (Organic Light Emitting Diode) is a visual interface that displays real-time environmental data including temperature, relative humidity, soil moisture and gas concentrations within the smart greenhouse control system. Data is communicated to the OLED display using I2C or SPI protocols from the Arduino microprocessor. Users can access real-time data from the environment inside of the greenhouse directly from the OLED display without using either a mobile device or computer. As well as providing real-time monitoring, OLED displays can also provide alerts if any of the environmental parameters exceed safe limits. OLED displays are energy efficient, offer high contrast ratios and are suitable for use in very small electronic systems.

Fig. OLED Display

9) *DC Fan:* The DC fan is employed in the smart greenhouse setup for the purpose of ventilation, temperature regulation, and air movement. The DC fan operates on DC voltage and generates air currents as a result of the rotation of the motor and the fan blades. The temperature is regulated by the DHT11 sensor, and when the temperature exceeds the limit, the Arduino sends a signal to turn on the fan using a relay. The fan is also employed to regulate humidity and ensure adequate air movement within the greenhouse.

Fig : DC Fan

10) *Water Pump:* The water pump is used in smart greenhouse systems for providing plants with automated irrigation. It is connected to Arduino using a relay module. The soil moisture sensor is always on to monitor the moisture level in the soil. Once the soil is dry, the relay will turn ON the water pump for providing plants with water. Once the soil reaches a certain moisture level, the pump will automatically turn OFF. This will ensure plants receive enough water for healthy growth.

Fig : Water Pump

11) *Tungsten Bulb:* Tungsten Bulb (Short Description): To provide artificial light for plant growth in the greenhouse, tungsten bulbs are utilized. The tungsten filament heats up and emits light when an electric current flows through it. Through a relay module, the Arduino regulates the lightbulb in the system, turning it on or off in response to light levels. This enables plants to carry out photosynthesis even at night or in low light.

Fig : Tungsten Bulb

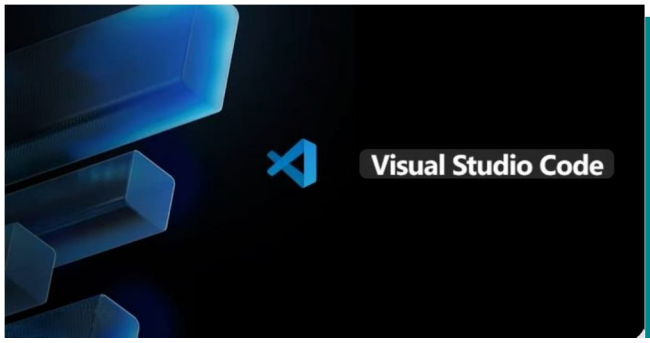
12) *9V Battery:* The 9V battery will be utilized as a portable energy source for the smart greenhouse system. It will be used to supply energy to the Arduino and other low-power components, like sensors and the OLED display. It will be connected to the Vin pin of the Arduino, where the regulator will convert 9V to 5V for proper functioning. It can be used only for testing and prototyping purposes or when AC supply is not available, but for actual usage, a stable power supply or rechargeable battery should be used.

Fig : 9V Battery

13) Software Tools

a) Visual Studio Code (VS Code): Visual Studio Code is a code editor developed by Microsoft. It allows developers to write, edit, and manage code in different programming languages. For IoT projects, VS Code is useful because it supports extensions, debugging tools, and project management features that make coding easier and more efficient.

b) Arduino IDE: Arduino IDE is software used to write and upload programs to Arduino boards like the Arduino Uno. It provides a simple interface to write code, compile it, and send it to the microcontroller, allowing projects to run smoothly on the Arduino board.



VI. RESULT

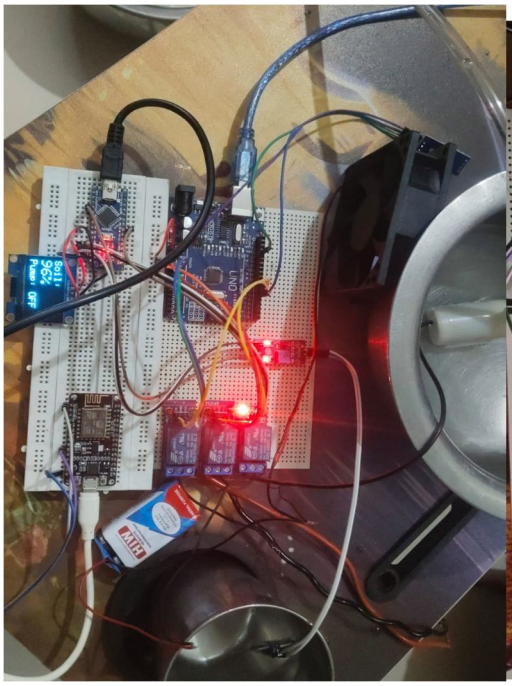


Fig : System is on

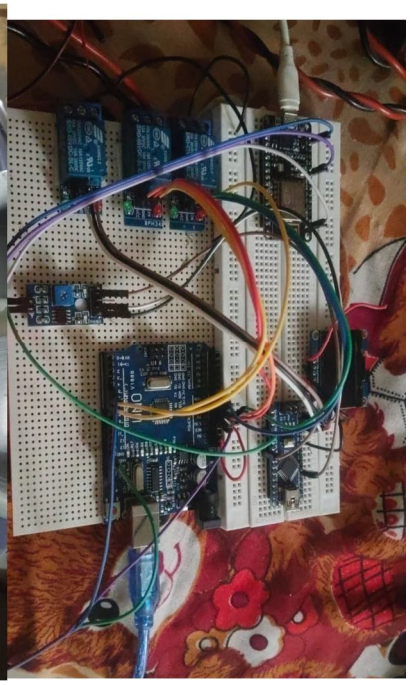


Fig : Circuit Connection

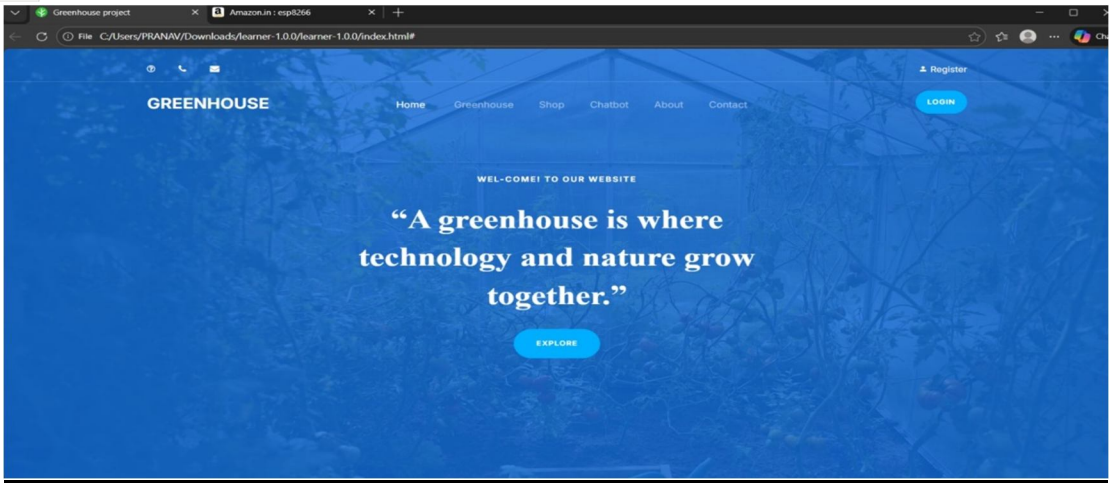


Fig : System Website

The Smart Greenhouse Monitoring and Control System is designed to automatically maintain the right environmental conditions for plant growth. It monitors important factors such as temperature, humidity, soil moisture, and harmful gases inside the greenhouse. The system uses different sensors, an Arduino UNO microcontroller, relay modules, and a WiFi module to create an automated greenhouse environment. By continuously checking the conditions and controlling devices automatically, the system helps plants grow in a healthy and suitable environment. The DHT11 sensor is used to measure the temperature and humidity inside the greenhouse. It contains special components that detect changes in the surrounding air. The sensor converts these measurements into digital data and sends them to the Arduino UNO. The Arduino compares the received values with preset limits. If the temperature becomes higher than the required level, the Arduino sends a signal to the relay module, which turns on the ventilation fan. The fan helps reduce the temperature and keeps the greenhouse environment comfortable for plant growth. The soil moisture sensor checks the amount of water present in the soil. It has two metal probes that are placed in the soil. These probes measure the soil's electrical conductivity. Wet soil allows electricity to pass more easily, while dry soil has higher resistance. The sensor sends this information to the Arduino. If the soil becomes too dry, the Arduino activates the water pump through the relay module. The pump supplies water to the plants. When the soil reaches the required moisture level, the Arduino automatically turns the pump off. This process helps avoid overwatering and also saves water. The MQ-2 gas sensor is used to detect harmful gases such as smoke, LPG, or methane inside the greenhouse. The sensor contains a special material that changes its resistance when it comes in contact with gases. This change creates a signal that is read by the Arduino. If the gas level becomes higher than the safe limit, the Arduino turns on an exhaust fan using the relay module. The fan removes polluted air from the greenhouse and keeps the environment safe for both plants and workers. The Arduino UNO works as the main controller of the entire system. It collects data from all the sensors, processes the information according to the program, and controls devices like fans and water pumps through relay modules. The relay modules allow the Arduino, which works with low voltage, to safely control high-power electrical devices. The Arduino continuously checks sensor data and updates the system actions to maintain stable greenhouse conditions. The system also uses an ESP8266 WiFi module, which provides internet connectivity. The Arduino sends sensor data to the ESP8266 through serial communication. The WiFi module then uploads the data to an IoT platform or cloud dashboard. This allows farmers to monitor greenhouse conditions from anywhere using a smartphone, tablet, or computer. They can see real-time sensor data, check past records, and even control devices if required. This IoT feature makes greenhouse management easier, more efficient, and more convenient.

VII. FUTURE SCOPE

The Smart Greenhouse Monitoring and Control System can be improved in the future by adding more advanced technologies. Additional sensors can be used to monitor factors like light intensity, carbon dioxide levels, soil nutrients, and air quality, which will help farmers maintain better growing conditions for plants. The system can also include Artificial Intelligence (AI) and Machine Learning (ML) to analyze sensor data and predict environmental changes. This would allow the system to automatically adjust conditions based on the needs of different crops. Another improvement is the development of a mobile application where farmers can easily monitor greenhouse data and receive alerts if any condition crosses the safe limit.

In the future, the system can also use solar energy to reduce electricity consumption and make the greenhouse more eco-friendly. These improvements will make the system more efficient and useful for modern smart farming.

VIII. CONCLUSION

The Smart Greenhouse Monitoring and Control System demonstrates how modern technology can improve agriculture and make farming more efficient. By using sensors, a microcontroller, relay modules, and WiFi communication, the system continuously monitors important environmental factors such as temperature, humidity, soil moisture, and harmful gases inside the greenhouse. Based on the data collected from the sensors, the system automatically controls devices like fans, water pumps, and ventilation systems to maintain suitable conditions for plant growth. This automation reduces manual work, decreases human errors, and ensures that plants always receive proper care. The system also helps in better management of resources. The soil moisture sensor controls irrigation automatically, preventing both overwatering and underwatering of plants. This helps save water and keeps the soil in good condition for plant growth. In addition, the MQ-2 gas sensor increases safety by detecting harmful gases and activating ventilation when necessary, keeping the greenhouse environment safe for both plants and workers. Another important advantage of the system is the IoT feature using the ESP8266 WiFi module. This allows farmers to monitor greenhouse conditions remotely using a smartphone or computer. They can check real-time data, observe environmental changes, and take action if any abnormal condition occurs. This remote monitoring makes greenhouse management easier and more convenient. In conclusion, the Smart Greenhouse Monitoring and Control System is a simple, automated, and cost-effective solution for modern farming. It helps maintain a controlled environment for healthy plant growth, reduces labor, and prevents wastage of resources. In the future, the system can be further improved by adding advanced sensors, data analysis, and mobile applications, making it even more useful for smart farming and sustainable agriculture.

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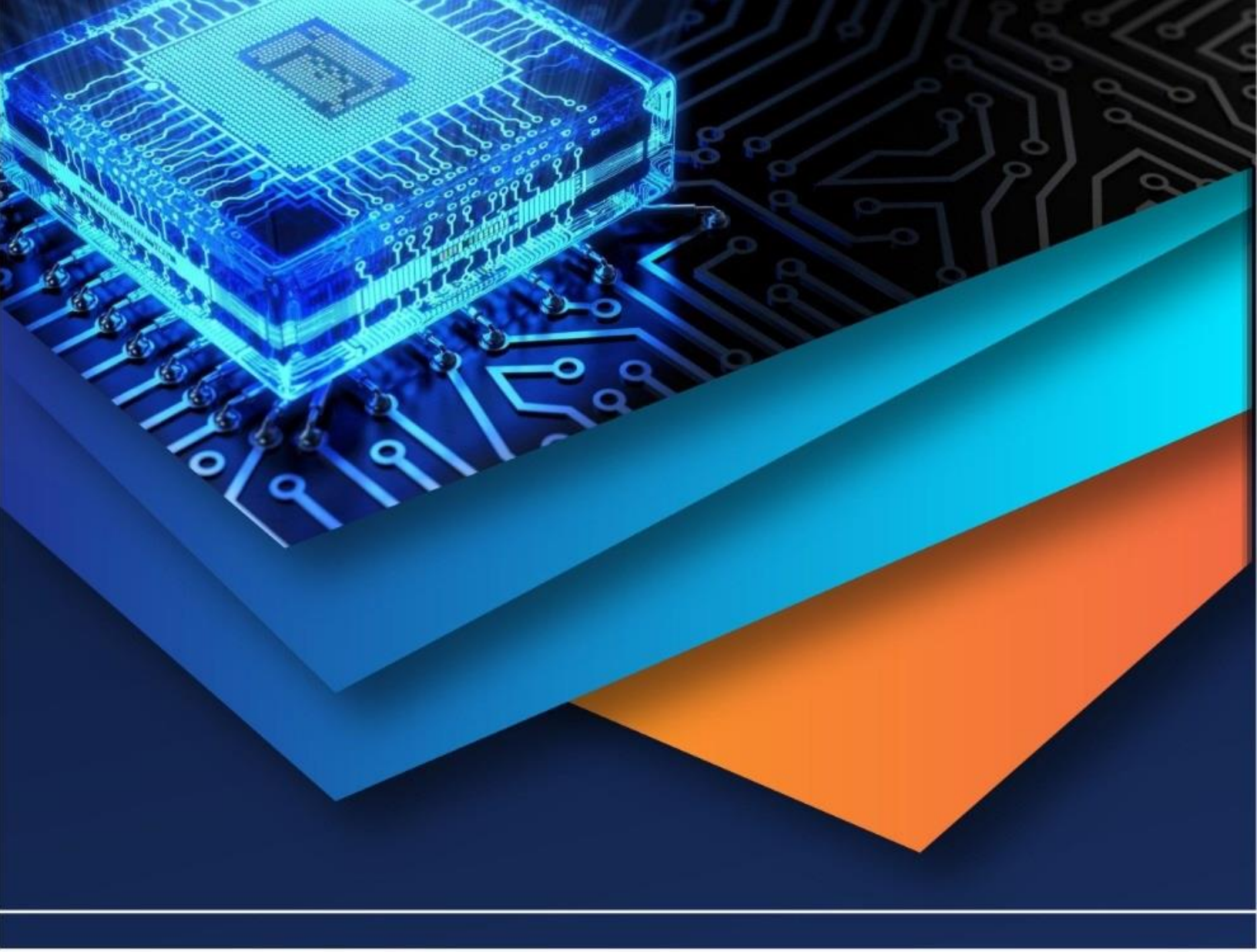

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