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Raspberry Pi based Soil Parameters Monitoring Device using Sensors

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Abstract*: The development in the field of technology has reduced the involvement of the manual work that is numerous new devices and techniques are replacing the conventional methods. Green house plantations , large scale gardening and farming are few among many trends that are being adopted in the present time. Reduction in the availability of laborers has urged for the more efficient techniques for the management of the plants. In order to overcome such situations, our project aims at monitoring soil parameters such as soil pH, moisture content and surrounding temperature. These three parameters are crucial factors for the proper plant growth. We are using a single processing chip Raspberry Pi as it is efficient and affordable. The real time data can be accessed by the owner of the land which helps him monitor the current soil parameters and can thus prevent the damage whenever there is an extreme variation in these parameters.

Keywords: Raspberry Pi, DHT11, pH meter, Moisture Sensor, Real time view

I. INTRODUCTION

These days new trend of growing exotic plants in green house, and variety of gardening such as hanging gardens are popular where extreme care of plants have to be taken. Agriculture being one of the major occupation of our country are also facing the threats due to water scarcity, variation in temperature and soil pH due to excessive use of fertilizers. A soil is considered fertile if it has the ability to supply essential plant nutrients, soil, and water in adequate amounts and proportions for plant growth and reproduction. The properties influencing soil fertility in most situations are sufficient soil depth for adequate root growth and water retention, good internal drainage which allows sufficient aeration, topsoil with sufficient soil organic matter and soil moisture, soil pH in the range 5.5 to 7.0 and presence of a range of microorganisms that support plant growth. Soil pH can be taken into account for the selection of appropriate application of fertilizers, as soil pH is considered as the major property contributing to soil fertility. Soil pH is a measure of the acidity or basicity of soil. It is measured in slurry of soil mixed with water and normally falls between 3 and 10, with 7 being neutral. If soil have a pH below 7,then they are considered acidic and soil having a pH above 7 is basic. Soil pH specifically affect plant nutrient availability by controlling the chemical forms of the different nutrients.

Soil moisture is the water held within the soil pores. Soil moisture is one of the main factors deciding crop yield, as it affects the water uptake of the plant. So measuring soil moisture always plays an important role in successful farm management. The conventional method to evaluate soil moisture content of 'look and feel' can be highly inaccurate. The use of moisture sensors helps to evaluate soil moisture helps to make relevant irrigation decisions.

The temperature at which most physiological processes go on normally in plants range from approximately 0 C to 40 C. Very high and very low temperatures cause injury effects. We can distinguish between direct temperature effects on physiological partial processes ,which allows us to draw conclusions about the physio-chemical processes involve and the direct effects of temperature on the plant as whole. For practical purposes we sub divide the subjects still further to effects of temperature on

A. early stages of growth (germination and vernalization)
B.) during the plants maturity
C. the dormant stages

A device capable of monitoring the above mentioned parameters is very much essential in the modern age where plantations are either spread on large-scale or extremely sensitive exotic plants are grown.

II. METHODOLOGY

The problem we have considered is to analyze the soil parameters such as soil pH, temperature and moisture values using Raspberry Pi and to send an alert message. Rising temperatures, drought, nitrogen uptake, plant disease and crop lodging are major threats to global crop production. While experienced planters could identify some issues at early stages, human observations are expensive, time-consuming and sometimes subjective. But usually the depletion in the nutrients of the soil goes unnoticed in the early stages.

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Environmentally to aid proper growth of plants, the device helps to control chemical applications of the soil and an automated irrigation system protecting the quality of surrounding land and water.

Hence using Raspberry Pi, we intend to determine the parameters of soil using sensors and alert the owner of the land. The processor Raspberry Pi is used to give better performance using programming language Python to take necessary action. The parameter is monitored by the kit (using pH sensor, temperature sensor and moisture sensor) and sends real-time data (using cloud) to the owner to take necessary actions.

The block diagram describes the working of the project model in a simple manner. The interconnection between different components of this project is shown and explained in this block diagram. The pH sensor ,and the moisture sensor is inserted in the soil sample and the other end is interfaced with the Raspberry Pi. The temperature sensor is also interfaced to the raspberry Pi. The Raspberry Pi stores the values and is programmed to analyze these values using the Python language. The automated water pump is interfaced to the Raspberry Pi through the relay circuit. The real-time data is viewed on mobile regarding the temperature, moisture and pH data indicating the nutrient level of the soil.

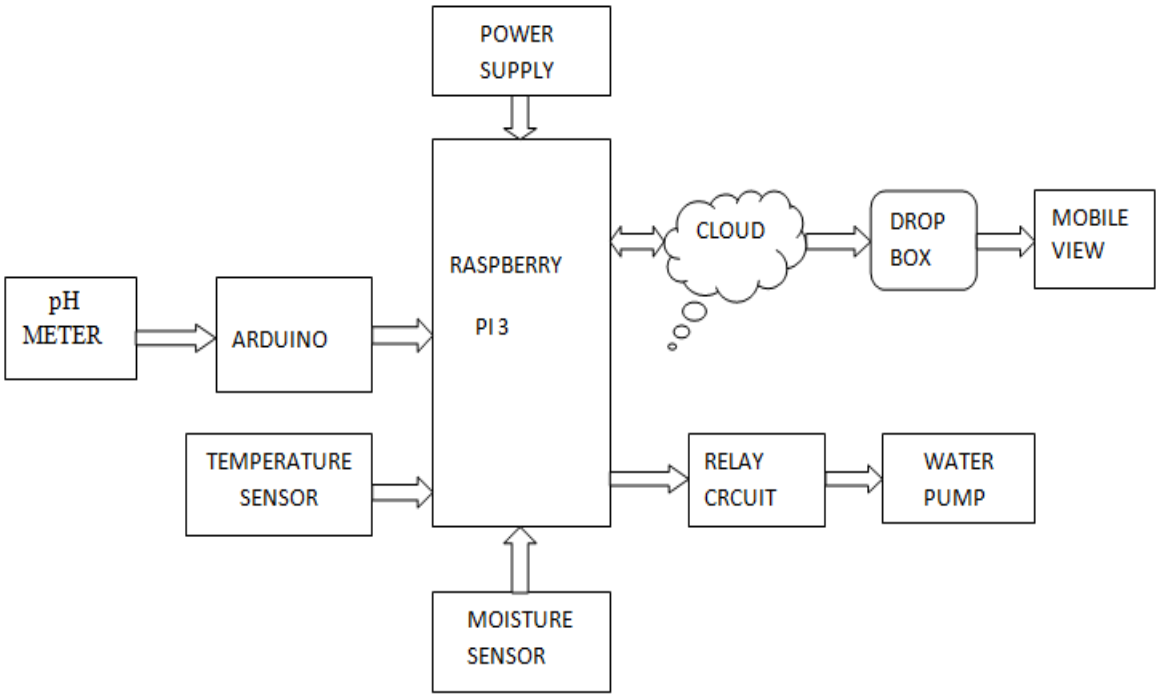


Fig. 1 Block diagram of the proposed project

III. MODULES

The different modules used in the device is as shown in Fig. 1. The modules used here are Raspberry Pi as the processor, different sensors such as DHT11 to find the temperature, moisture sensor and a pH meter. An analog to digital converter is required to comprehend the pH values for which Arduino is used. Different modules used in the proposed device is as given below:

A. Raspberry Pi

The Raspberry Pi is considered as a computer on its own as it can do everything a desktop computer can. It was developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and developing countries. Several generations of Raspberry Pi have been released over the years. The Raspberry Pi is extremely flexible due to its design, and because of this it will let you connect to it from another computer via a system called SSH (Secure Shell). The GPIO port is one of the most powerful tools at the Raspberry Pi's disposal, allowing you to connect directly to an electronic circuit to control it. In such a system, the Pi is referred to as a microcontroller. This is what makes the Raspberry Pi great for big projects, as you can use it to program a machine or circuit. The OS to be used can be decided by the user however, Raspberry Pi Foundation provides several versions of Raspbian, a Debian based Linux distribution for download, as well as third-party Ubuntu, Windows 10 IOT Core, RISC OS. Python and Scratch can be used as the main programming language but also supports many other languages.

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Fig. 2 Raspberry Pi

B. Arduino

Arduino is used in the project as an analog to digital converter. The Arduino board features an Atmel ATmega328 microcontroller operating at 5 V. The storage found is 2 Kb of RAM, 32 Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, that means the executing speed is about 300,000 lines of C source code per second. The pin definition is 14 digital I/O pins and 6 analog input pins. There are other feature such as a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source, for example a 9 V battery, when running a program while not connected to the host computer.



Fig. 3 Arduino

C. pH Sensor

pH meter measures the activity of the hydrogen ions in the solutions to determine the pH of the sample. This activity is compared to pure water (a neutral solution) using a pH scale of 0 to 14 to determine the acidity or alkalinity of the sample solutions. An ADC is interfaced with the pH meter in order to convert into digital values.

D. Moisture Sensor

Soil moisture sensors is used to measure the volumetric water content in soil. Since the direct measurement of free soil moisture requires removing, drying, and weighting of soil sample, soil moisture sensors measure the volumetric water content indirectly by electrical resistance, dielectric constant, or interaction with neurons, which are some of the properties of soil as a proxy for the moisture content. The sensor detects the moisture of the soil and if the content is low, the module output is high otherwise the output will remain low.

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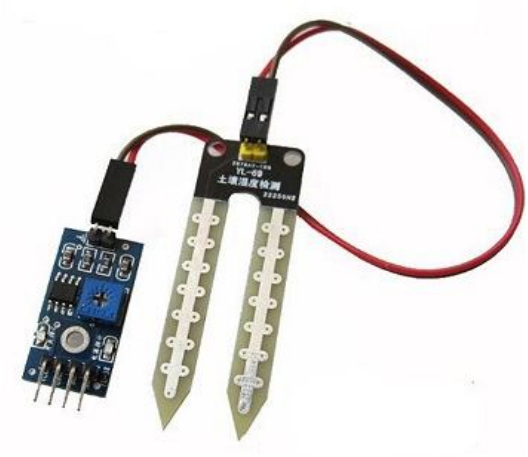


Fig. 4 Moisture Sensor

E. Temperature Sensor

DHT11 sensor is the sensor used to detect temperature, which provides calibrated digital signal output of the temperature and humidity. A collection of dedicated digital modules helps the user to interface DHT11 and ensure that the product has high reliability and excellent long-term stability. The sensor is usually connected with a high-performance 8-bit microcontroller. It also includes resistive sense of wet components and an NTC temperature measurement device, and DHT11 uses a simplified single-bus communication. Single bus means only one data line, the system of data exchange, controlled by a single bus for complete communication. Device (master or slave) through an open-drain or tri-state port is connected to the data line and does not allow the device to send data over the bus, while other devices use the bus; single bus usually require an external high which is achieved by using 5.1kΩ pull-up resistor, so that when the bus is idle, its status is high. Since DHT11 is a master-slave structure, only when the host calls the slave, the slave can answer, the host access to devices must strictly follow the single-bus sequence. If the chaotic sequence is found then the device will not respond to the host.

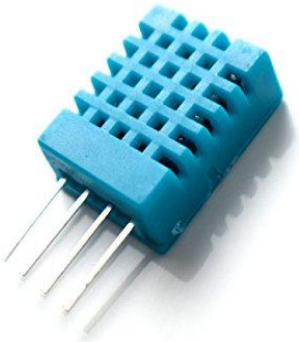


Fig. 5 Temperature Sensor

F. Relay

Relay is used to isolates two circuits electrically and connect them magnetically by using electromagnetic properties. They are very useful devices and used for switching on of one of the circuit by another one while they are completely separate. They are often used to whenever interfacing of an electronic circuit working at a low voltage to an electrical circuit which works at very high voltage has to be done. For example, a relay can make a 5V DC battery circuit to switch a 230V AC mains circuit. Thus a small sensor circuit can drive, say, a fan or an electric bulb. It is used here to switch on and off the water pump.

G. Python

Python is a popularly used general-purpose, high-level programming language. Python is very easy to understand emphasizing high code readability, and its syntax is very efficient allowing programmers to express concepts in fewer lines of code than in C++ or Java. Python is the language compatible with Raspbian Jessie OS. Python supports object-oriented programming, imperative and functional programming or procedural styles. It features a dynamic system and automatic memory management and has a large and comprehensive standard library. So Python is used for codes included in this project.

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IV. WORKING

The Raspberry Pi requires a power supply of 5V. IP Scanner is a software used to detect all the IP addresses of the devices connected to a particular network. Therefore IP Scanner is used to detect the IP address of the Raspberry Pi which enables us for remote login using Secured Shell(SSH) communication protocol. SSH provides a secure channel over an unsecured network in a client-server architecture. PuTTy is used to support SSH protocol. It is a free an open source terminal emulator, serial console and network file transfer application. Raspberry Pi is uploaded with the Raspbian Jessie operating system which is a Debian based operating System. DHT11 sensor and soil moisture sensor are interfaced to the of the GPIO pins of Raspberry Pi. pH meter is connected to one of the pins of Arduino which acts as an ADC, since Raspberry Pi is not compatible with analog value. Arduino is serially connected to Raspberry Pi. Arduino IDE is used for writing program codes for Arduino. Python is used in Raspberry Pi as programming language. Based on the pH value the information regarding the nutrient levels in the soil is obtained. The output screen consists of temperature value and information regarding nutrients. Based on the soil moisture sensor values the water pump is switched on.

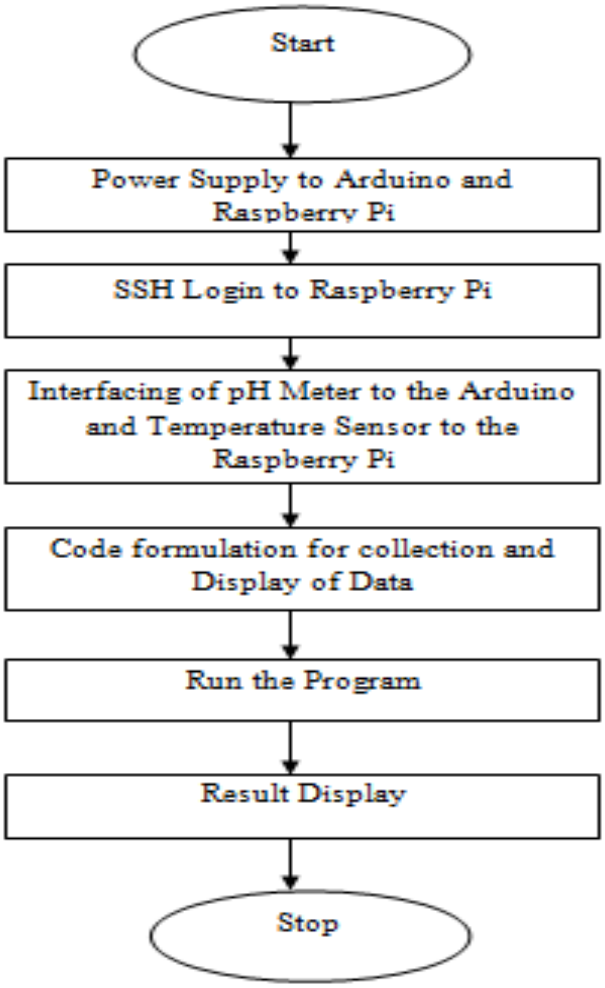


Fig. 6 Flow Chart

V. RESULTS

The environmental temperature, pH value and moisture of the soil sample is successfully measured using the temperature, pH and moisture sensor interfaced with the Raspberry Pi module. The obtained values are analyzed by the Raspberry Pi. The expected result is to access to real time data comprising temperature, moisture, pH value and information about the nutrient level of the soil on the mobile with the help of cloud. An automated water pump should also start water supply based on the low soil moisture content. The pH value between 5.5 to 6.5 is considered optimum for most of the plants as all nutrients in soil are available for the uptake. The accurate display of result for a soil with optimum pH obtained is as shown.

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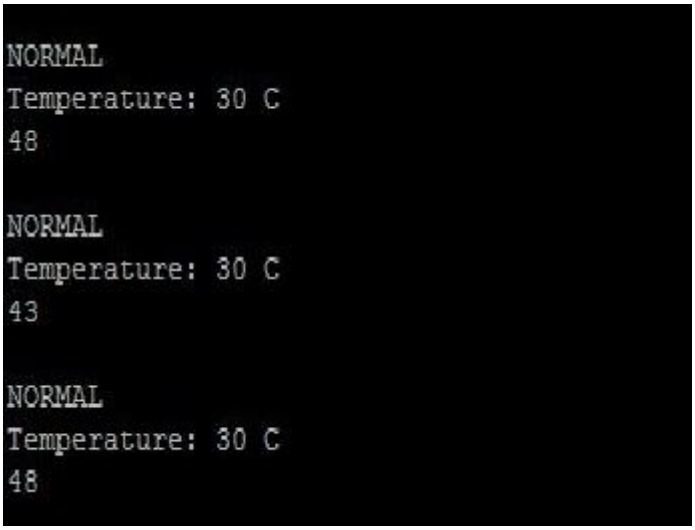


Fig. 7 Result display for soil with optimum pH

The soil with pH less than 5.5 is considered acidic and the nutrients nitrogen and phosphorus are deficient in the soil . So when we considered a soil sample with enough lemon juice to make it acidic, the results displayed was as shown in Fig 8.

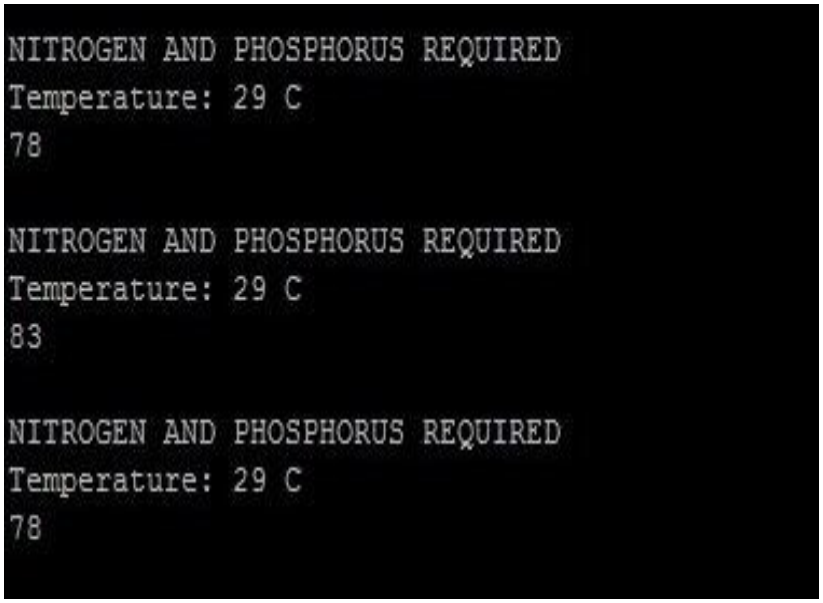


Fig. 8 Result display for acidic soil

VI. CONCLUSION

The main objective of this paper is to design a fully automated monitoring system. The system provides a real time system which monitors soil pH, temperature and soil moisture efficiently. The system valves are turn ON or OFF automatically depending upon the moisture content. The system also provides the efficient information regarding the soil pH and soil nutrients. The system provides a real time analysis to the owner to monitor variation in the parameters. Using this system, one can save manpower, water to improve production and ultimately increase profit. We can add more environmental sensors to this module to make it more efficient.

VII. ACKNOWLEDGMENT

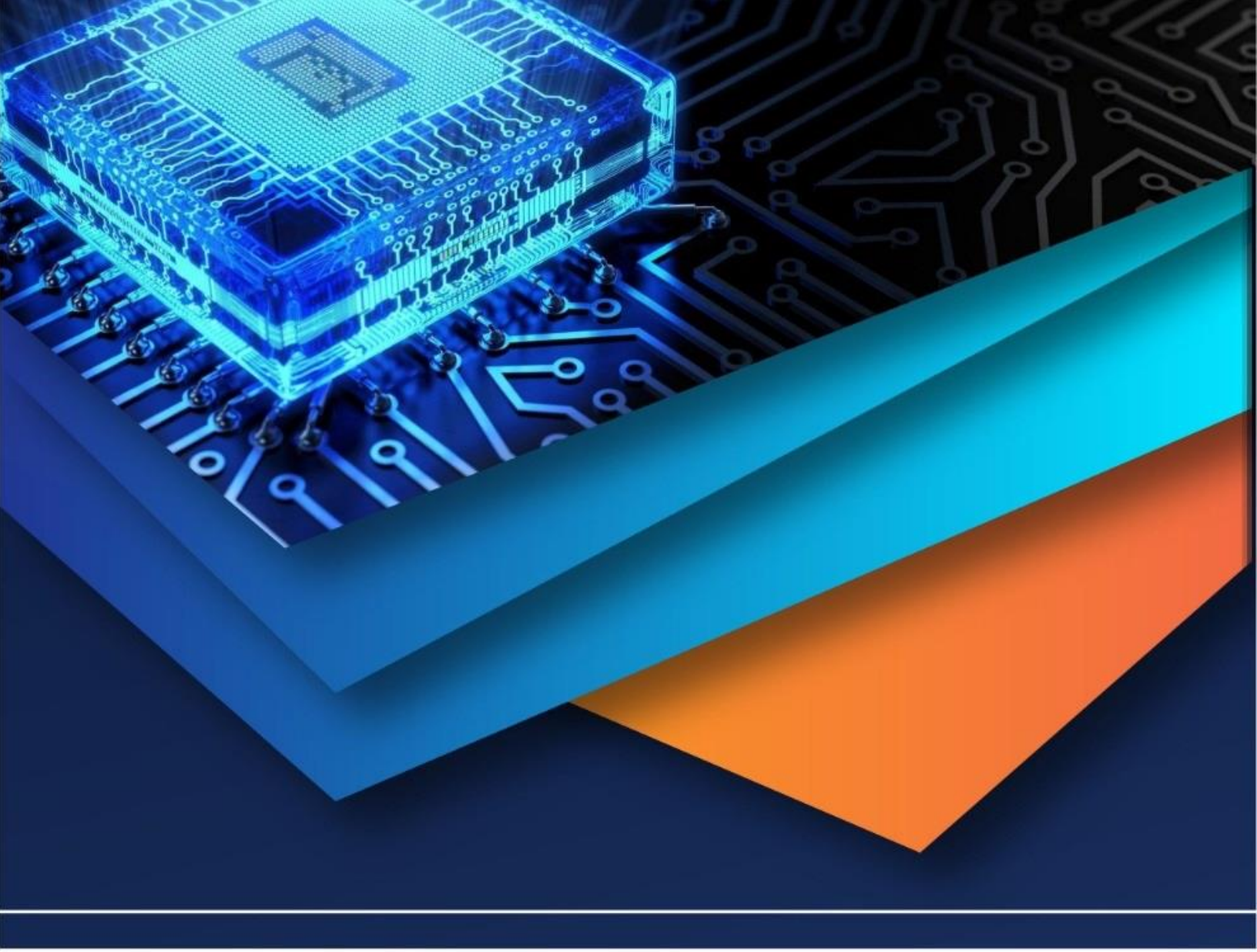
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