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Home Automation System Using Raspberry Pi and Temperature Sensor

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Abstract*: *The purpose of the research paper is to propose a home-automation system i.e. controlling A/C via relays by measuring the temperature and humidity readings by using a DHT11 sensor. Weather conditions play a very important role in our life. Collecting data about different parameters of the weather is necessary for planning in home and environments. Recent development in Internet of Things made it possible to collect the data in-situ. This paper presents the detection of real-time temperature and humidity using raspberry pi on cloud. Smart home is a house that uses information technology to monitor the environment, control the electrical appliances and communicates with the outer world. A smart home automation system has been developed to automatically achieve some activities performed frequently in daily life to obtain more comfortable and easier life environment. The system can monitor and control the house's equipments from anywhere in the house. IoT (Internet of Things) is the network of physical objects-devices, vehicles, buildings and other items embedded with electronics, software, sensors and network connectivity- that enables these objects to collect and exchange data. The internet of things allows objects to be sensed and controlled remotely across existing network infrastructure.

Keywords*: *Raspberry Pi, DHT11, ESP8266, Home Automation, Internet of Things, Temperature

I. INTRODUCTION

The Internet of things (IoT) is the network of everyday objects – physical things embedded with electronics, software, sensors and connectivity enabling data exchange. Basically, a little networked computer is attached to a thing, allowing information exchange to and from that thing. By using IoT objects to be sensed or controlled remotely through existing network, it gives opportunity to connect physical world with computer-based systems.

IoT improves efficiency, accuracy, economic benefits along with reduced manpower. Temperature has an impact on all activities surrounding us. A precise determination of temperature is a vital factor in countless industries and different fields of science. Temperature sensors possessing temperature-dependent properties that can be measured electrically contain resistors, semi-conductor mechanisms such as diodes and thermo-couples.

The sensor utilized here is the DHT11 sensor. Raspberry Pi, acting as data logger processes the converted output of sensors from analog to digital. The logged data can then be transferred to a desktop or any other monitor which has GUI for further analysis.

Home automation or Smart Homes can be described as introduction of technology within the home environment to provide convenience, comfort, security and energy efficiency to its occupants.

Adding intelligence to home environment can provide increased quality of life. With the introduction of the Internet of Things (IoT), the research and implementation of home automation are getting more popular. Home automation is the process of controlling home appliances automatically using various control system techniques.

The electrical and electronic appliances such as fan, lights, outdoor lights, fire alarm, kitchen timer, etc. can be controlled using various control techniques. Among the various techniques utilized for home automation, the Raspberry Pi based home automation is one of the most widely used home automation technique.

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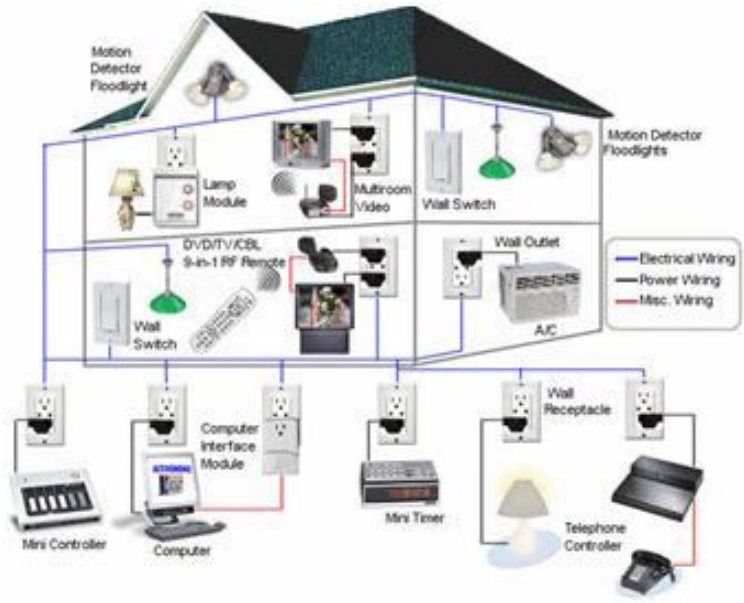

Fig.1 Home Automation System [6]

The custom Raspberry Pi has relays fixed on, which will control all the operations of sensors. The internet will be connected via LAN or Wi-Fi. The internet acts as a master since the entire control process is taken care of by an online server-side program (PHP module). The user just has to login in to the specified web page during the time of initialization and in case there is a need to change the automation settings. The web-page will be coded in such a way that it provides complete control to the user over the automation process such as timings and conditions for the automation process.

The Raspberry Pi is a low cost, small and portable size of computer board. It can be used to plug-in to computer monitor or television, keyboard, mouse, pen-drive, etc. Raspberry Pi has in-built software such as Scratch which enables users to program and design animation, game or interesting video. In addition, programmers can also develop script or program using Python language; it is main core language in Raspbian operating system.

Suppose a light bulb to be switched on or off is connected via a relay. The gate of the relay is connected to a GPIO Pin of the ESP8266 Wi-Fi chip. This chip also has an embedded web server and an IP address. It provides a web page interface to turn on or off the light bulb using a value 1 or 0 received via the post method (PHP). To do this, the embedded web page of the ESP8266 is loaded by specifying its IP address from the Raspberry Pi. The Raspberry Pi and the ESP8266 are connected via Wi-Fi. Power consumption of the home can be recorded using either a current-transformer or a Hall-effect transducer. The current-transformer or the Hall-effect transducer is connected via A/C main supply of the house to an A/D converter. This A/D converter is connected to the GPIO pins of the Raspberry Pi and the values that the A/D converter is calibrated and proportional to the power consumption. The values are read by the Raspberry Pi using the Python module “Wiring Pi”. For measuring power consumption a current transformer is more accurate than a hall-effect transducer but the one used in the project is a Hall-effect transducer.

One of the applications of this maybe to use temperature sensor to sense temperature and to switch on the A/C via a relay when the temperature exceeds the threshold value.

II. ESP8266 AND DHT11

A. ESP8266

The ESP8266 module [1] is an extremely capable wireless programmable microcontroller board. The ESP8266 Wi-Fi Board is a SOC with integrated TCP/IP protocol stack that can give any secondary microcontroller access to your Wi-Fi network. The ESP8266 board is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor and therefore this is more suitable to be used as a sensing node that is capable to sense the data from various wirelessly connected IoT sensor nodes and send data to the central server. The embedded web server in the ESP8266 can be developed using C/C++ or Lua. By default the ESP8266 comes with a web server written in Lua. Some features of ESP8266 are [2]:

1) Operating Voltage: 3.3V
2) Clock Speed: 26MHz to 52MHz

3) System Memory:<45kB
4) Flash Memory: upto 128MB
5) Programming Languages: C,C++, Wiring
6) I/O Connectivity: UART, GPIO

Fig.2 ESP8266 [7]

B. DHT11

The DHT11 is a low cost temperature and humidity sensor. It is not the fastest sensor around but its cheap price makes it useful for experimenting or projects where you do not require new readings multiple times a second. The device requires only three connections to the Pi, +3.3V, ground and one GPIO pin. The device itself has four pins but one of them is not used. The modules have three pins and are easy to connect directly to the Pi's GPIO header.

The four pin device will require a resistor (4.7K-10K) to be placed between Pin 1 (3.3V) and Pin 2 (Data). The three pins are connected to the Pi as shown in the table:

TABLE I
DHT PIN TO GPIO PIN

DHT PIN	SIGNAL	Pi PIN
1	3.3V	1
2	DATA/OUT	11 (GPIO 17)
3	NOT USED	-
4	GROUND	6 OR 9

DHT11 consists of a humidity sensing component, a NTC temperature sensor (or thermistor) and an IC on the back side of the sensor.

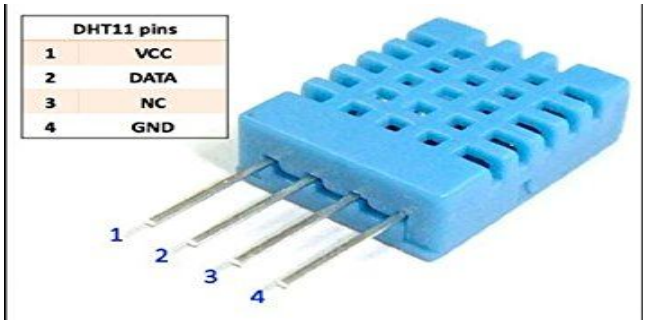

Fig.3 DHT11 [8]

For measuring humidity it uses the humidity sensing component which has two electrodes with moisture holding substrate between them. So as the humidity changes, the conductivity of the substrate changes or the resistance between the electrodes changes. This change in resistance is measured and processed by the IC which makes it ready to read by a microcontroller.

On the other hand, for measuring temperature these sensors use a NTC temperature sensor or thermistor. A thermistor is actually a variable resistor with its resistance varying with temperature. The term "NTC" means Negative Temperature Coefficient which means resistance decreases with increase in temperature.

Some facts about the ranges of DHT11 sensors are:

*1)*Humidity range: 20-90%
*2)*Humidity accuracy: +/-5%
*3)*Temperature range:0-50˚C
*4)*Temperature accuracy:+/-2%
*5)*Operating Voltage:3-5V

III.HOW TO START USING RASPBERRY PI

A. *Plugging Into Raspberry Pi*

For plugging in to Raspberry Pi the following steps are to be followed [3]:

1) To start, slot the SD card into the SD card slot on the Raspberry Pi
2) Plug in the USB keyboard and Mouse into the USB slots on the Raspberry Pi
3) Make sure that the monitor or TV is coiled on, and the right input is selected (e.g. HDMI, DVI, etc.)
4) Link the HDMI cable from the Raspberry Pi to the monitor
5) If the Raspberry Pi has to be linked to the internet, plug in an Ethernet cable into the Ethernet seaport consecutive to the USB seaports

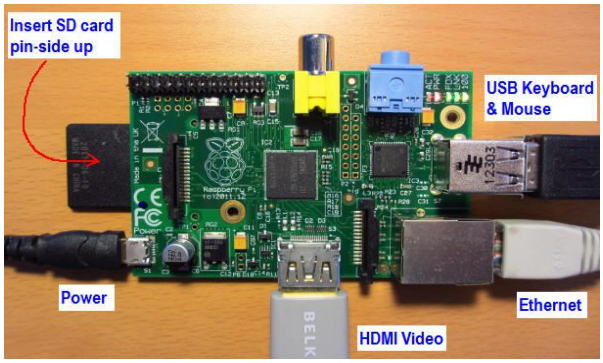

Fig. 4 Plugging into Raspberry Pi [9]

IV.LOGGING INTO RASPBERRY PI [4]

A. Once the Raspberry Pi has finished the boot procedure, a login punctual will appear. The default login for Raspbian is username pi alongside password raspberry. After logged in discern the order line promptpi@raspberrypi~$ will be displayed

B. To use the graphical user interface, use startx command and press Go in the keyboard

TABLE II
COMPARISON OF MODELS OF RASPERRY PI

	Raspberry Pi	
	Model A	Model B
CPU	Broadcom ARM11 SoC	Broadcom ARM11 SoC
Clock Speed	Up to 1GHz	Up to 1GHz
Memory	256MB	512MB
USB	1 USB Port	2 USB Port
Network	None	Onboard Ethernet

V. NOOBS

New Out Of The Box Software (NOOBS) is an easy operating system installation manager for Raspberry Pi.
To set up a blank SD card with NOOBS:

1) Format an SD card which is 8GB or larger as FAT
2) Download and extract the files from the NOOBS zip file
3) Copy the extracted file onto the SD card that has just been formatted, so that this file is at the root directory of the SD card

A. The following are included in NOOBS:

1) Raspbian
2) Pidora
3) LibreELEC
4) OSMC
5) RISC OS
6) Arch Linux

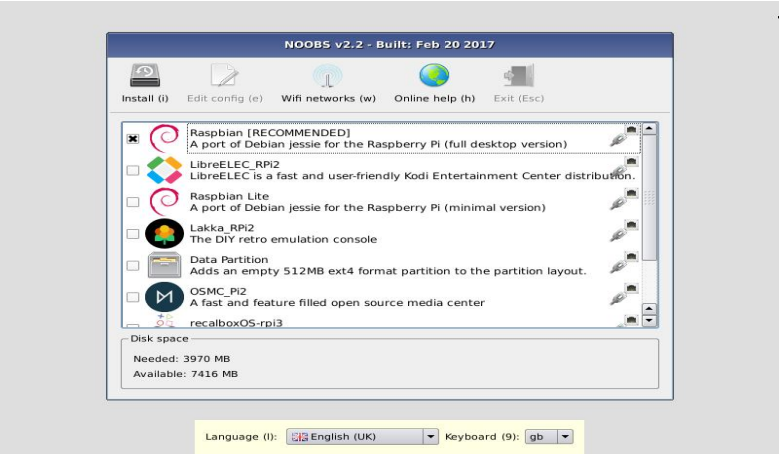

Fig. 5 NOOBS [10]

VI. PROPOSED SYSTEM

The system employs a DHT11 sensor to sense the temperature and humidity readings. The output is displayed on a SSH terminal and the readings recorded. Whenever the temperature and humidity readings cross the threshold value, a short text message is sent to a mobile number using python script and the A/C is turned on via a relay which is connected to the GPIO pins of the raspberry pi. The gate of the relay is connected to a GPIO pin of the ESP8266 Wi-Fi chip. This chip also has an embedded web server and IP address which provides a web page interface to turn on or off the A/C.

The short text message informs the user that the A/C is going to be switched on via the relay and that the temperature reading has crossed the threshold value. Power consumption of home is recorded using Hall-effect transducer. The text message is sent via an online messenger (using API) using python coding to deliver the message. The power reading is read using a Hall-effect transducer. DRV411 sensor signal conditioning integrated circuit is introduced to reduce the noise by the Hall-effect transducer. Hall-effect transducers deliver a voltage signal proportional to the AC or DC magnetic field. The A/D converter is connected is connected to the GPIO pins of the Raspberry Pi. The values are read by the Raspberry Pi using Python module “Wiring Pi”. The DHT11 is connected to a breadboard and the pins are connected to the GPIO pins via jumper wires. After logging into the Raspberry Pi, the readings are available at one second intervals. Python coding is used to output the readings on the SSH terminal i.e. the computer monitor which has been connected to the raspberry pi. Linux is the operating system used.

Relays: A solid state relay is used which is much smaller and easier to control than a mechanical relay, using Pi’s GPIO pins.
One has to drive the input pin constantly to keep the relay on (just like a mechanical relay). So if something fails with that signal, then the power goes off. To avoid that one has to design another circuit that can sustain itself. A 4- channel relay board is used in this project to control four different loads. It has all the necessary components and connections like base current limiting resistor, fly back diode, LED indicators and header for connecting it to other devices. [5]

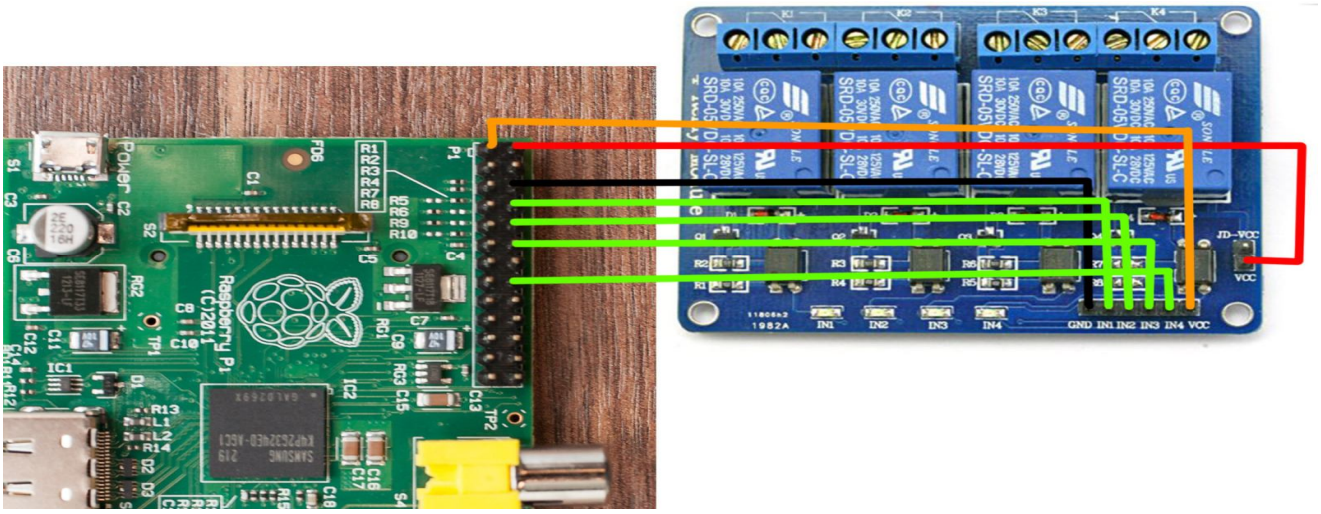

Fig.6 Connecting Raspberry Pi to Relay [11]

Hall-effect transducer: A Hall effect sensor is a transducer that varies its output voltage in response to a magnetic field. They are available with either linear or digital outputs. Hall-effect sensors consist basically of a thin piece of rectangular p-type semiconductor material such as gallium arsenide (GaAs), indium antimonide (InSb) or indium arsenide (InAs) passing a continuous current through itself. When the device is placed within a magnetic field, the magnetic flux lines exert a force on the semiconductor material which deflects the charge carriers, electrons and holes, to either side of the semiconductor slab. This movement of charge carriers is a result of the magnetic force they experience passing through the semiconductor material.

As these electrons and holes move side wards a potential difference is produced between the two sides of the semiconductor material by the build up of these charge carriers. Then the movement of electrons through the semiconductor material is affected by the presence of an external magnetic field which is at right angles to it and this effect is greater in a flat rectangular shaped material. The basic fundamental principle underlying the Hall-effect is the Lorentz force. One advantage with the Hall-effect transducer is that they are non-intrusive and one disadvantage of current transformers is the development of hysteresis over a period of time.

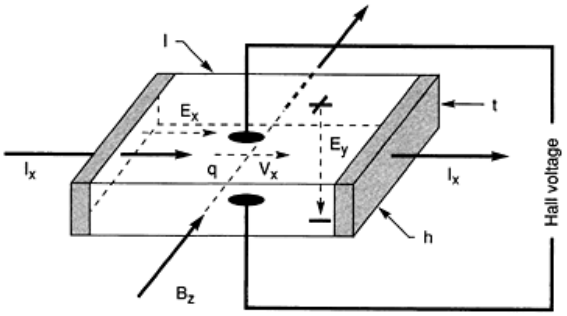

Fig.7 Hall-effect Transducer [12]

VII. SCOPE OF THE PROJECT

A. The system will be used to inform the user about varying temperature and humidity readings via messages
B. The system will be used to inform the user about switching on the A/C
C. The system will be used to inform the user about the power consumption
D. The threshold temperature and humidity readings can be set by the user
E. The A/C will automatically be switched on using relays
F. A timer can be set to regulate the time for which the A/C will remain switched on
G. Python coding will be used to program the Raspberry Pi for temperature and humidity readings and for controlling relays and messaging
H. The system is compact and does not require much time to assemble
I. Home automation via relays can be used to switch on or off the fan and lighting system using the temperature sensor(DHT11) for readings

J. Weather inside the house can be regulated with ease using the home automation system

VIII. ADVANTAGES

A. The system is cheap and easy to configure and rebuild
B. The sensor DHT11 used is cheap and easily available
C. Provides efficient way to monitor weather inside the house
D. Temperature and Humidity readings can be controlled with ease
E. User gets to know when the A/C has been switched on
F. Electric usage can be controlled by using timer to time the duration of usage of the A/C
G. Fast action to drastic climate changes
H. Power consumption controlled by user

IX. LIMITATIONS OF THE SYSTEM

A. Smart phone to be used for configuring home automation
B. If timer is not used, the temperature can drop to that set on the A/C which may not be comfortable
C. If timer is not used, it can lead to lump-sum electric bills which may not suit the user
D. If the system is kept switched on while not at home, it could lead to unnecessary bills
E. Cost of solid state relays may not be affordable
F. If the system or sensor is kept at an isolated place, it may lead to incorrect readings
G. Requirement of SSH terminal for displaying readings

X. CONCLUSIONS

The project presents a home automation system using a thermal and humidity sensor i.e. DHT11 which is used to read temperature and humidity readings and display it to a SSH terminal. SMS is sent to user defined phone numbers about abnormal temperature readings and the A/C switched on using relays. The proposed home automation system has been confined to A/C only but can be expanded to include switching on or off of the fans and lighting systems. Relays can be expanded from 4 to desired number to include the number of connections required by the home automation system. The results show that higher accuracy and precision is achieved via the DHT11 sensor. The mobile numbers can be stored temporarily or permanently and SMS sent from an online messaging site using python programming. The proposed system can be of much great help to users who want a steady temperature control system and want to control their home environment as they desire.

XI. ACKNOWLEDGMENT

We express sincere thanks and gratitude to all who helped in the completion of this work. The work would not have been possible without the excellent guidance, constant encouragement, suggestions and constructive feedback by Satish Narayanan who helped in completion of the work. We are indebted to his co-operation and enthusiasm towards completion of the work.

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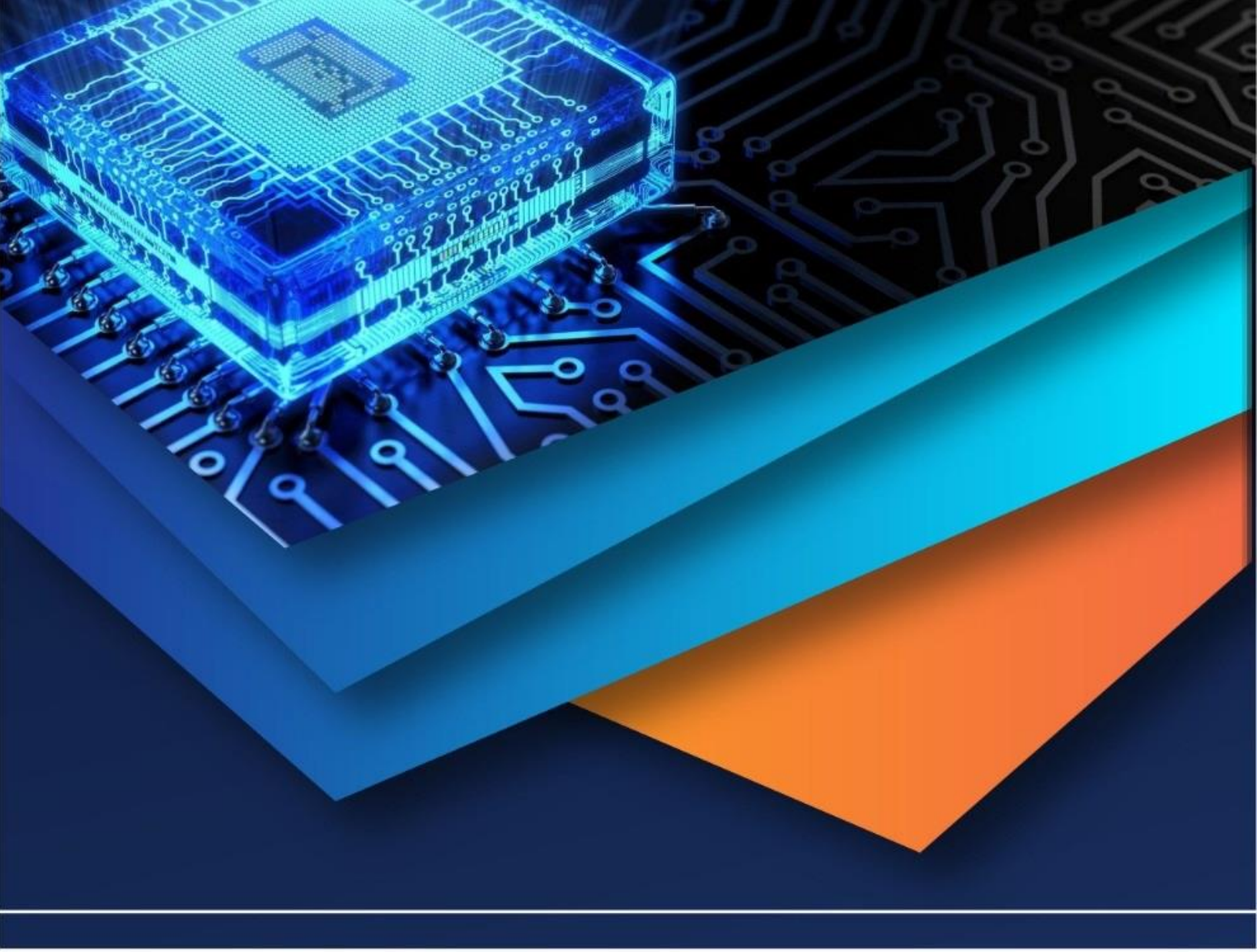

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