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NeuraHome: IoT- Driven Intelligent Living with Real-Time Cloud & Weather Adaptation

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Abstract: ***The rapid growth of Internet of Things (IoT) technology has made digital home systems more efficient, safe and user-friendly.***

This project focuses on designing and developing a NeuraHome:IoT-Driven Intelligent Living with Real-Time Cloud & Weather Adaptation using theESP32 microcontrollerintegrated with Firebase cloud services. The system monitors temperature and humidity using a DHT11 Sensor, along with electrical parameters such as voltage ,current, frequency and energy consumption using the PZEM004T module.

All the data is sent in Realtime to the Firebase Realtime Databasevia Wi-Fi,allowing users to monitor and control their home remotely through a mobile application developed using Expo Go.The system provides intelligent control of electrical appliances using relay modules.

The fan turns on by itself when the temperature gets too high. This happens when the temperature goes above a level that we have set. We can also control all the electrical appliances using the mobile app.We can even set the lights to turn on and off at times.

The system also looks at the weather forecast to make decisions.The system is really good because it combines control, connection to the cloud and real time monitoring.

This helps us manage energy better makes life easier for users and keeps them comfortable. It is a solution, for modern smart homes because it can be made bigger if we need it to be.

Keywords: IoT, ESP32, Firebase Realtime Database, Energy Monitoring, PZEM004T, DHT11 Sensor, Relay Control, Mobile Application, Expo Go, Cloud Based Monitoring, Temperature-Based Automation Time-Based Control, Weather API Integration.

I. INTRODUCTION

The Internet Of Things technology has really changed the way we live in our homes these days. Instead of traditional electrical systems, digital home automation allows users to control appliances remotely, monitor conditions in Realtime and improve both convenience and energy efficiency.

One big problem we have now is that we are using a lot of energy. Many people do not know how electricity they are using, which means they are wasting energy and getting big bills. This project is trying to solve that problem by putting home automation and real-time energy monitoring so people can see how much power they are using and make some changes. The system is made with the ESP32 microcontroller, which lets it connect to Wi-Fi and talk to things easily. It uses a DHT11 sensor to check the temperature and humidity so you can turn on a fan when it gets hot.

You have to do that yourself. To track electricity usage, the system integrates a PZEM004T module that measures voltage, frequency, current and energy consumption. This data is sent to the cloud using Firebase Realtime Database, enabling users to monitor it anytime through a mobile app developed with Expo Go. The app also allows remote control of electrical appliances along with scheduled operations.

By combining automation, cloud connectivity and energy monitoring, this project offers a practical and cost-effective digital home solution.It promotes efficient energy use, enhances comfort and represents a step towards more sustainable and intelligent living environment.

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II. METHODOLOGY

A. Block Diagram

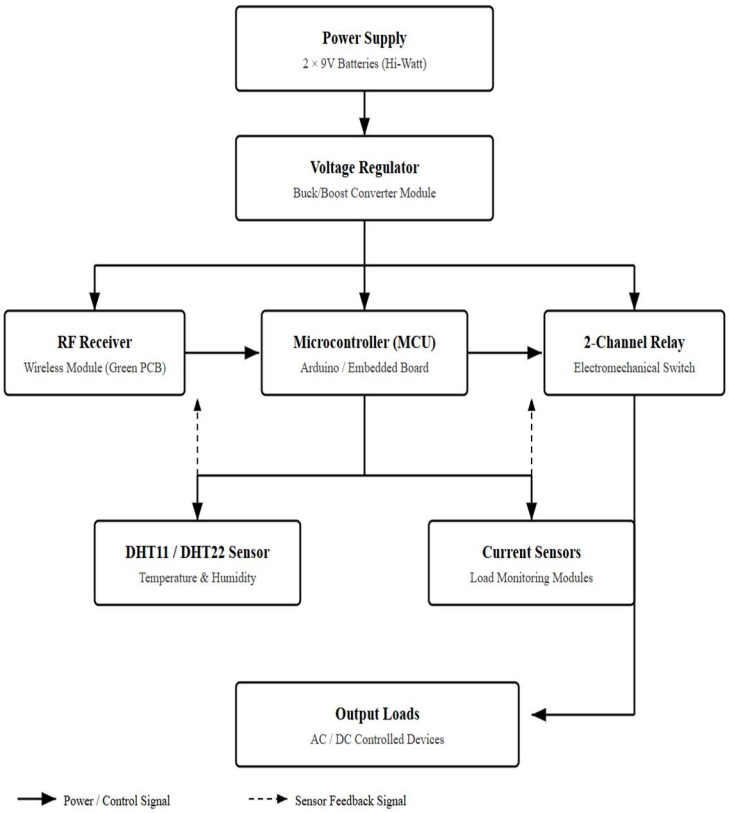


Fig 1: Block diagram of NeuraHome

The NeuraHome system has ESP32 microcontrolleracts as the main controller.The power supply module provides energy to the system and the PZEM004T energy monitoring module measures electrical parameters like voltage,current,frequency and energy consumption.The DHT11 sensor calculates the temperature and humidity. The two channel relay module is connected to the electrical appliances these are used to control the switching of the electrical appliances manually via app.The ESP32 sends all the data to the cloud using Firebase Realtime Database,allowing the users to monitor and control the appliances through a mobile app developed using Expo Go. The APP has user friendly interface with easy navigation showing the weather status including the temperature,humidity,energy parameters and has a manual control.the app sends notifications to the mobile whenever it is about to rain and cloudy alerting the user. The app is integrated with weather API that gives the weather forecast from near weather station.

B. Circuit Diagram

This circuit works with the ESP32 microcontroller. It is the part that controls everything. When we turn on the system the ESP32 microcontroller connects to our Wi-Fi network. Then it sets up a connection, with the Firebase Realtime Database. The ESP32 microcontroller does all of this on its own.This cloud database acts as a bridge between hardware system and the mobile application developed using the Expo Go.After this establishment the ESP32 reads the data from DHT11 sensor and PZEM004T.These readings are processed by the ESP32 and uploaded to the Firebase in Realtime.The Expo Go retrieves this live data from Firebase and displays it to the user in a user-friendly interface.This data is displayed in the app and user control it using mobile app irrespective of location with an internet connection.The two channel relay module connected to the fan and bulb.Users can manually control these appliances through the app by sending commands to the Firebase.The ESP32 continuously checks the database for any control commands and controls the relays accordingly.

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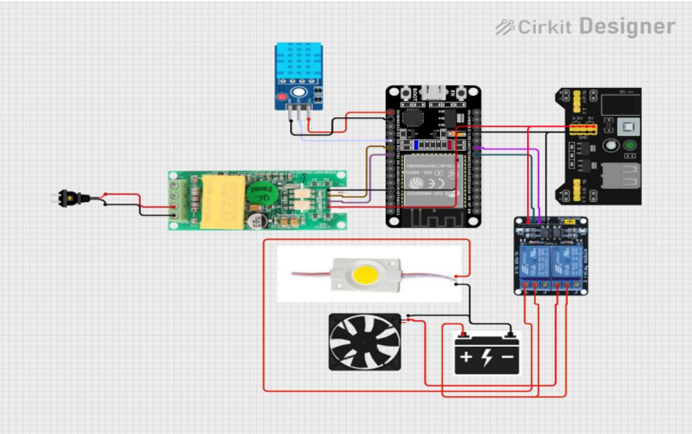


Fig 2: Circuit diagram of NeuraHome

C. *Flow Chart*

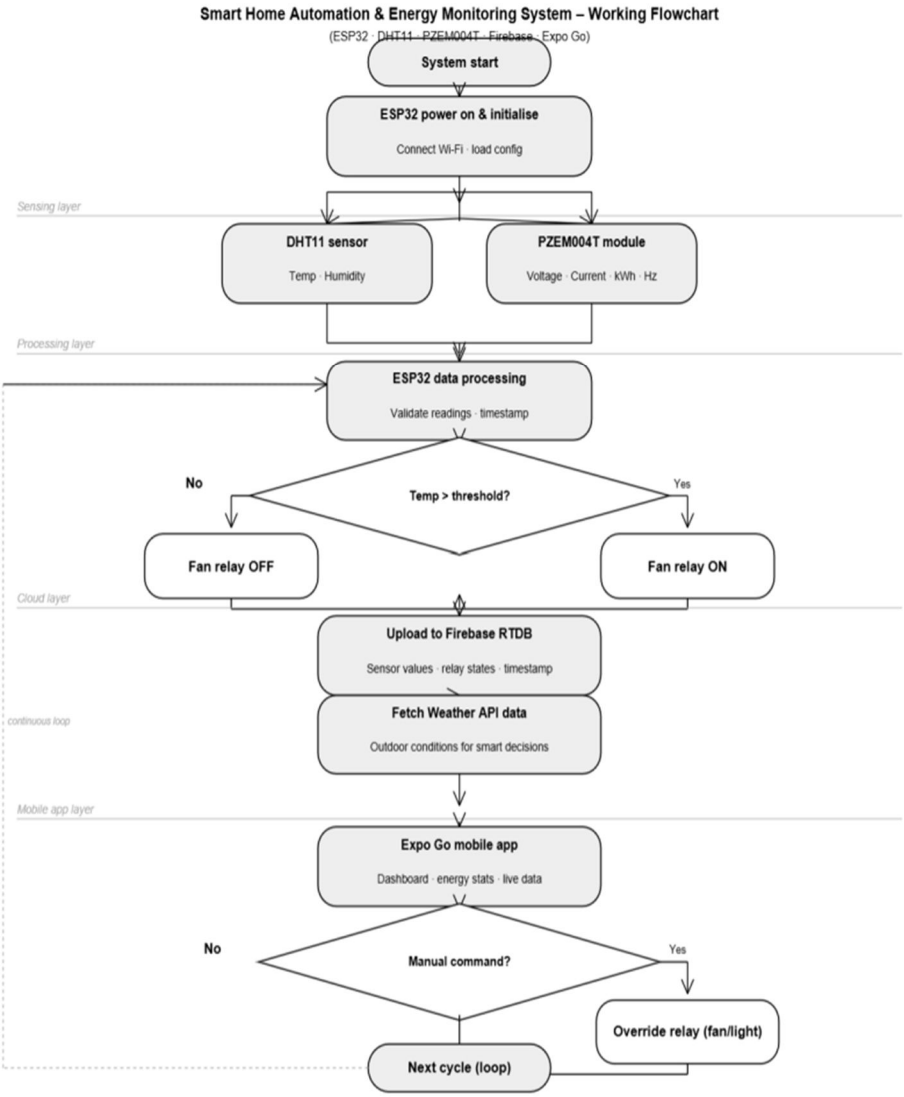


Fig 3: Workflow of NeuraHome

D. Components Specification

1) ESP32 Microcontroller

The ESP32 is a good microcontroller that does not cost a lot of money. It is also very powerful. Can do lots of things. The ESP32 has Wi-Fi and Bluetooth which's very useful. People use the ESP32 a lot for Internet of Things projects because it can do things and does not use a lot of power. The ESP32 is like the boss and it can connect to the internet because it has Wi-Fi and Bluetooth. The ESP32 has some cool features, like a special processor that can do two things at the same time Wi-Fi and Bluetooth and lots of pins that can be used to connect other things to the ESP32.

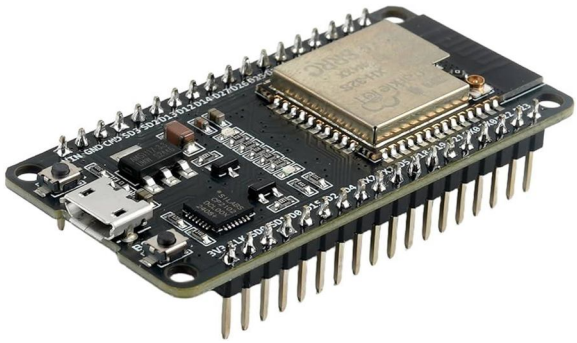


Fig 4:ESP32(microcontroller)

2) PZEM004T

PZEM004T is an AC energy monitoring module use to measure electrical parameters such as voltage, current,power and energy consumption. It communicates with microcontrollers through UART protocol. This module helps in analysing power usage in real-time with specifications frequency measurement, energy measurement with high accuracy.



Fig 5:PZEM004T

3) DHT11

DHT11 is a sensor. It measures temperature and humidity. It provides calibrated digital output providing easy interface with microcontrollers. The sensor is cost-effective and suitable for basic environmentalmonitoring .It is widely used in automation projects.It has specifications such as digital single wire communication.

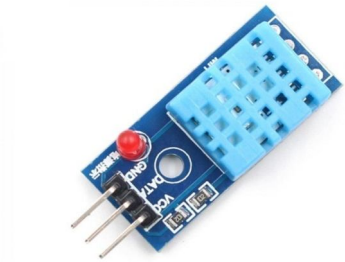


Fig 6:DHT11

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4) Two Channel Relay Module

It is used to control two electrical devices like light and a fan using a microcontroller.Each channel works as a separate switch,allowing independent control of devices,It uses a low voltage signal to safely turn high voltage appliances ON or OFF,protecting the controller.



Fig 7:Two channel relay module

5) Jumper Wires

These are flexible electrical wires used to connect components in electronic circuits. They are used prototyping and testing connections on breadboards and developing boards like ESP32.Jumper wires allow quick and easy connection without soldering. They are essential in IoT and embedded system projects.



Fig 8:Jumper Wires

6) Power Supply Board

It is used for the DC voltage like 5V and 3.3V that Arduino and other modules need.It ensures stable operations of the system. This has overload protection and regulation with applications in embedded systems, microcontroller power supply and control panels.

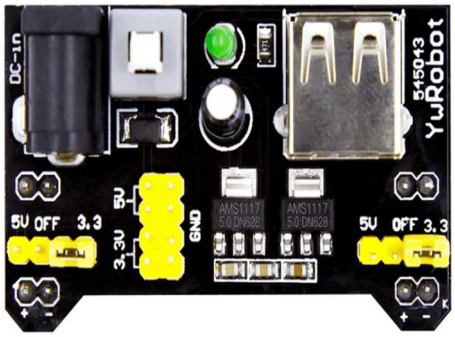


Fig 9:PowerSupply Board

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III. SOFTWARE IMPLEMENTATION

The mobile application was developed using React Native via the Expo Go toolchain, enabling seamless cross-platform deployment across both Ios and Android from a single JavaScript or TypeScript code based, Firebase serves as the real-time backend database, continuously streaming live sensor parameters including voltage ,current, frequency, energy, temperature and humidity directly to the app.To compliment the onboard DHT11 sensor readings, the Open Weather REST API is integrated to provide broader atmospheric data based on the homes location, delivering a comprehensive and real-time smart home monitoring experience.

A. Arduino IDE

We use this for a things. It helps us write code compile it and then upload it to the ESP32 microcontroller.
The Firebase Realtime Database is used for storing sensor data. It also helps synchronize this data in time with the mobile application. We use the Firebase Realtime Database to keep everything up, to date.

B. Firebase Realtime Database

Used for storing and synchronizing sensor data in real time with the mobile application.

C. React Native

Used to develop the cross-platform mobile application for displaying environmental data.

D. Expo Go

Used to run and test the mobile application directly on smartphones.
The software part is really important when we are making the proposal system because it helps us to keep an eye on things as they happen and manage the data at the time. The incorporation of Arduino IDE, Firebase, React Native and Expo Go ensures the effective communication of the hardware with the mobile application.

IV. SIMUALTION RESULTS

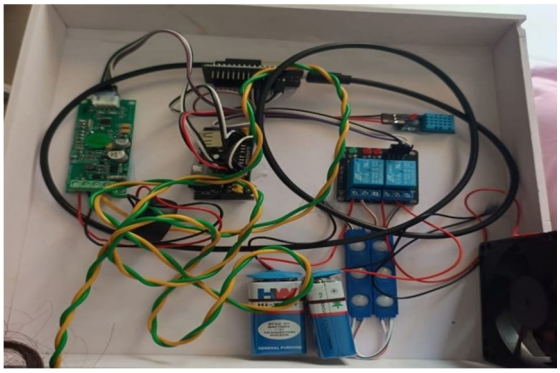


Fig 10:Hardware setup of NeuraHome

This setup works like a small smart control system built around a central microcontroller,most likely an ESP32 development board,which acts as the “brain” of the whole circuit.Power comes from the two 9 volts batteries,which feed into the power module on the left to provide a stable voltage for all the components.The microcontroller is connected to a DHT11 sensor.The DHT11 sensor checks the temperature and humidity around it. It also uses a water sensor to check for moisture.The DHT11 sensor and the water sensor keep sending information to the microcontroller. The microcontroller gets temperature, humidity and moisture data from the DHT11 and water sensors. The microcontroller gets all this information, from the DHT11 sensor and the water sensor. Depending on these conditions the microcontroller sends a signal to the relay module, which works like a switch.This relay is connected to the fan and light,it controls the fan on the right side when activated it allows power to flow to the fan turning it ON and OFF.All the parts are linked with wires. They all share the same ground. Thishelps everything work together. The system can sense what is, around it.It then figures out what to do.It acts on its own after that.It does all this on its own. The system and its parts all work together smoothly.

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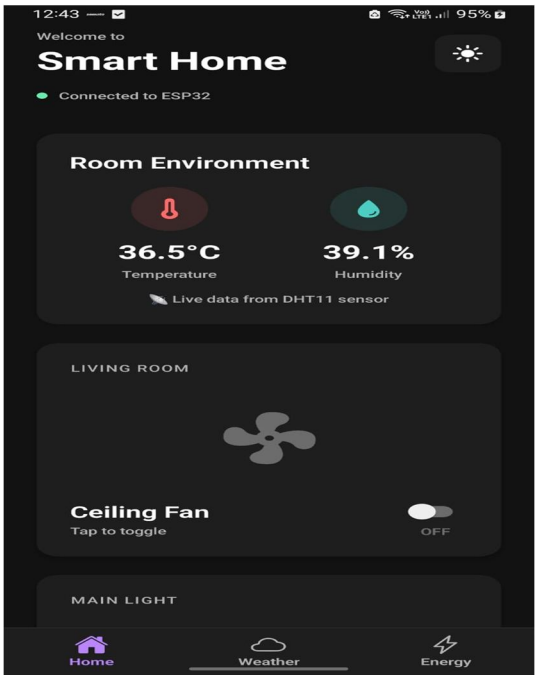


Fig 11

This showsthe main page when the app is opened displayingtemperature and humidity.It has a fan section that shows the status of fan and has a manual button to turn it ON or OFF whenever required.The button navigation bar has weather and energy icons.

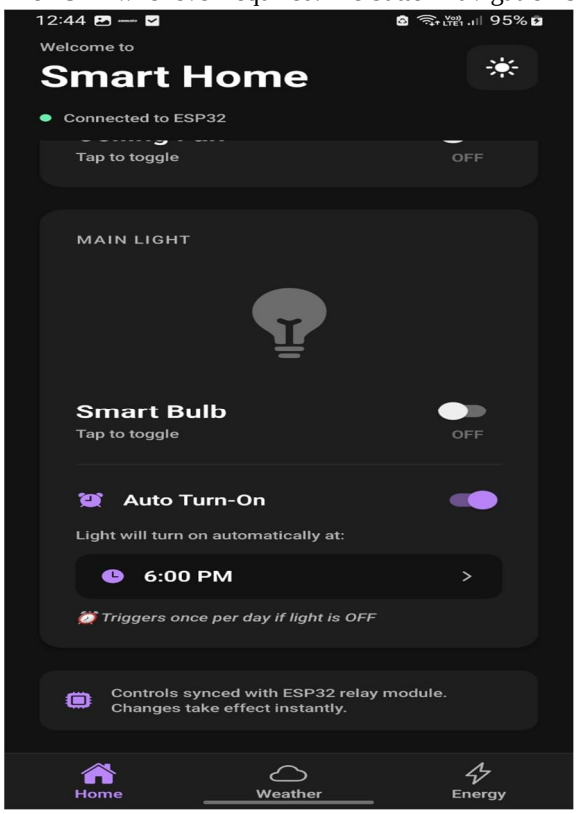


Fig 12

This page consists of the bulb section which allows switching off and on of the bulb based upon the time set. It also has a button to switch off and on.

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Fig 13

This page shows the weather report of Visakhapatnam since the app is connected to the near weather station. We can connect to anyother weather station if we wanted, to change the city based upon our preference.It gives the reports of the previous day as well.

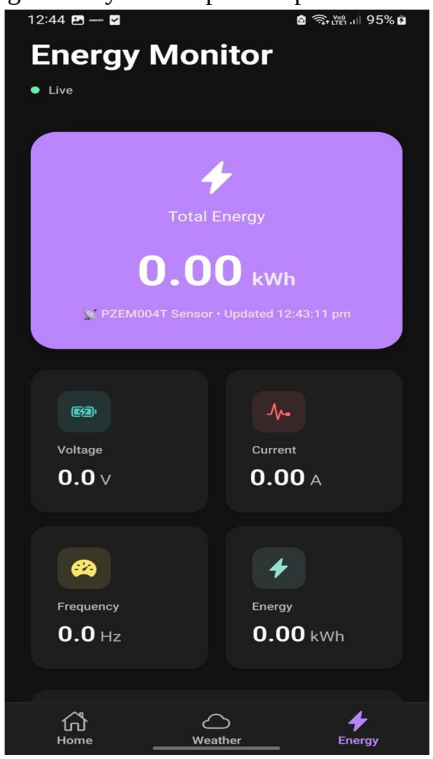


Fig 14

This page shows the energy consumed along with the voltage,current and frequency which later can be used to calculate and estimate the power consumed there by predicting the current bill.
“It also sends prompt messages alerting the user like to carry an umbrella if it is going to rain and etc.”

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V. APPLICATIONS

1) Residential SmartHomes: Automatic monitoring home appliances for comfort and energy saving.
2) Energy Management Systems: Tracking power consumption in homes, offices or small industries.
3) Industrial Monitoring: It monitors electrical loads and environmental conditions in a small scale in industrial set-ups.
4) Agricultural Environments: Monitoring temperature and humidity for green house or storage automation.

VI. ADVANTAGES

1) Real-Time Monitoring: You can keep an eye on things in time with Real-Time Monitoring. This means you can check on things like voltage and energy and current and frequency from anywhere you are. You can also see what is going on with the environment, like the temperature and humidity. This is really helpful because you can do it from anywhere.
2) Remote Control: You can control appliances from far away using the Expo Go app, no matter where you are.
3) Energy Efficiency: The app shows you how much energy you're using right now so you can see where you're wasting power and use less electricity, which means lower bills.
4) Time-Based scheduling: You can set your lights to turn on or off at times, which is really convenient and helps save energy.
5) Cloud-Based Scalability: The system uses Firebase so it's easy to make it bigger or smaller as needed. You can use it on lots of different devices without any problems.
6) Cost-Effective: We built it using parts so its practical for regular people to use in their homes.
7) Weather- Aware Decision Making: Integration with the Open Weather API ithelps in automation.

VII. CONCLUSION

We have developed an IoT based NeuraHome:IoT-Driven Intelligent Living with Real-TimeCloud & Weather Adaptation system using ESP32 microcontroller. It integrates environmental monitoring via DHT11 sensor and real-time electrical measurement using the PZEM-004T module with data stored in the Firebase Realtime Databasefor cloud connectivity and remote access.The Expo Go mobile application is very useful. It lets you monitor things in time and control appliances. This makes life easier and more efficient. The system is good, for home automation and energy management because it is affordable and can be made bigger if needed. The ESP32 microcontroller and Firebase Realtime Database are parts of this system.

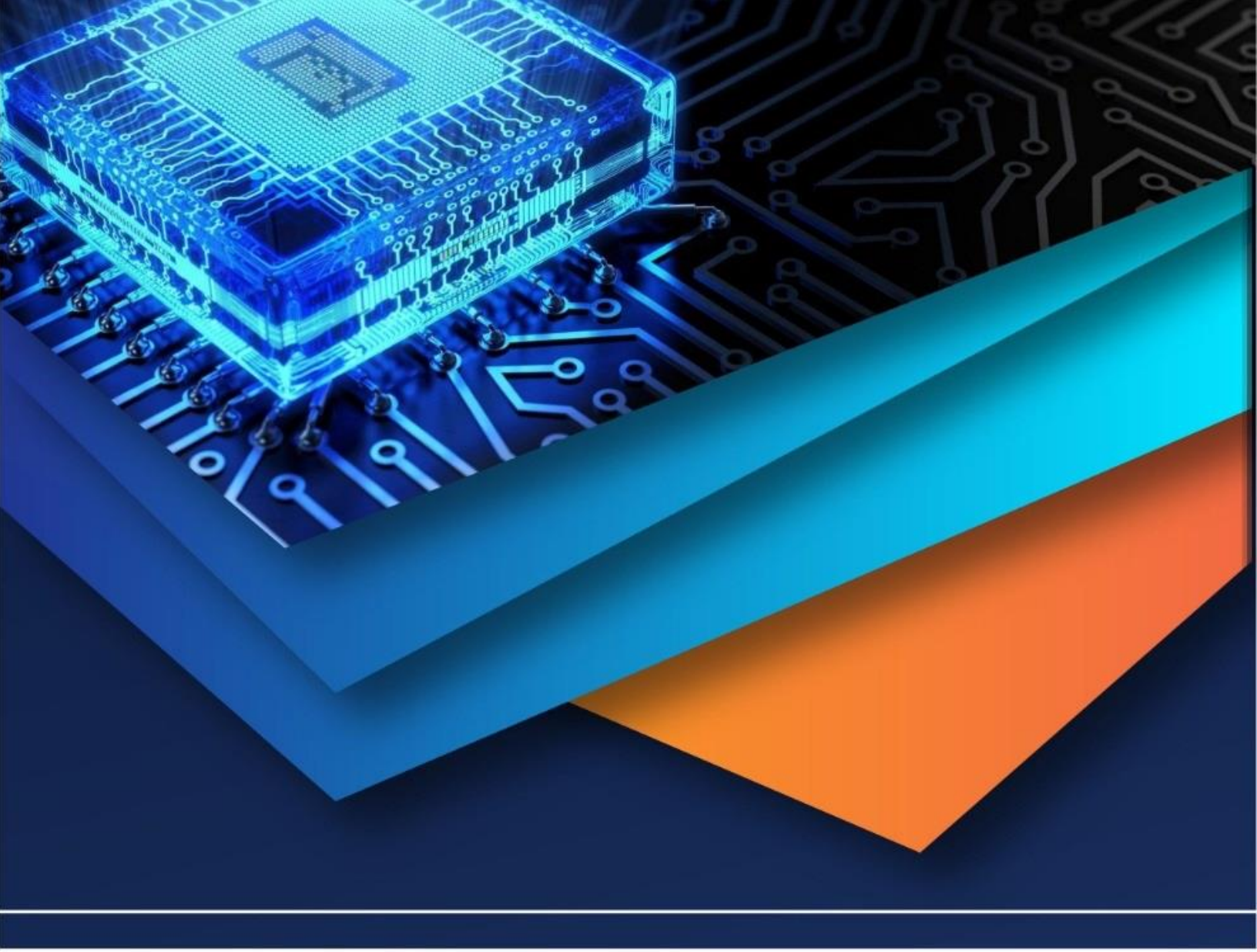
VIII. ACKNOWLEDGEMENT

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