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Wind Turbine Parameters Estimation andVisualization through Dashboard

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Abstract: ***This Project is about tracking the real-time health of all the parts of the windmill. Apart from these the live parameter obtained from the sensors such as the altitude, location, wind direction, temperature, current, voltage, pressure, power, and altitude which would be further sent to a dashboard having some decision-making ability on predefine dataset. The Webpage has 3 sections the first one which includes data obtained from all sensors that is visualized in the form of donuts and bar charts. A chat-bot has been implemented as well for assistance purpose and booking an appointment. Average power for a period of last five newly inserted data is calculated as well for day range specific as well. Lastly a caution button has been implemented that would trigger an alert in case value of power and rpm surpasses the limit set. The second section consists of the service alert page in which the client can raise issues which would be stored in the firebase and finally the last section that is an about us page describingabout the makers and what the project is all about.***

Keywords: Sensors, webpage, dashboard, firebase, chat-bot.

I. INTRODUCTION

Wind energy is a renewable and powerful resource. It is readily available, abundant, and clean source of energy. The variable speed generation for a windmills attractive because maximum efficiency can be achieved at all the wind velocities. The failure of Windmill results in system downtime and repairing or replacement expenses that significantly reduce the annual income. These failures result for more systematic operation and maintenance scheme to ensure the reliableness of wind energy systems.

To monitor all the electrical wind turbines /transformers, to maximize the power generation. Track the optimum conditions for power, rpm and send an alert in case value exceeds the initial values and monitor parameters like temperature, pressure Current. Assign a repair crew member to resolve the issue on the notification received to know the information of all the parameters being monitored to determine the cause of the failure and to predict the future steps. It also has an analytical dashboard which helps in aiding through chatbot. However, the decisions can be taken as per the smart data available i.e., live sensor data, past sensor data, device metadata Technology that can address this issue partially.

The users of this system involve:

1) Automating the management of wind farms, optimize maintenance and reliability , and eventually reduce the cost to a great extent.
2) Increase the efficiency of the Windmill.
3) The Utility manager could monitor all the electrical windmill specifications so that he can maximize the power generation.
4) In this Project we would determine the power average over five-day interval as well as day wise which would be determined by the amount of data that would be fetched from firebase
5) Do visualization through a web application using graphs,donut, charts in a real time environment.

II. LITERATURE REVIEW

1) *Methods for Advanced Wind Turbine Condition Monitoring and Early Diagnosis: (2018) Authors:* Md Liton Hossain ID, Ahmed Abu-Siada ID and S. M. Muyeen: This paper presents a comprehensive review on common faults, signals and signal processing methods for condition monitoring and fault diagnosis of wind turbine systems. Advantages and limitations of each technique have been highlighted.
2) *Feasibility of a fully autonomous wireless monitoring system for a wind turbine blade: (2016) Authors:* O.O. Esu, S.D. Lloyd, J. A. Flint, S. J. Watson: This paper has introduced the concept of a fully autonomous monitoring system for a wind turbine blade which has its own in-built power source. A fundamental difference between the system proposed and commercial systems is the purpose— while commercial systems focus on ice detection and loading, the proposed system focuses on damage detection.

3) *Performance optimization of wind turbines: (2012) Author:* Zijun Zhang, In this paper a data-mining framework for optimization of wind turbines performance was introduced. The framework included construction and optimization of data-driven models. Data-mining algorithms were applied to identify accurate wind turbine models from the collected data from wind turbines.

III. OBJECTIVES

A. The maintaining and servicing of windmills determined by their efficiency and reliability.
B. Order placement immediately in case of exhaustion of inventory and goods.
C. Analysis of the downtime and reasons for it.
D. Ensure that desired power is achieved from wind farm to grid and wind plants.
E. Maximize the Windmill power generating capability.
F. To obtain real time insights of failures

IV. WORKING

1) The data would be collected from the turbine of a windmill which would include Altitude, Temperature, Pressure, Wind Speed and Direction.
2) The Data obtained would be transmitted to ESP8266 forprocessing.
3) Further storing of the data would be done in Firebase which would be incorporated with a web application.
4) Finally, data would be visualized in the form of graphs, charts, donuts from the user side through a web application designed using Html, CSS, and JavaScript.

Below is the picture demonstrating the various components and resources (Software, Hardware) that make up the entire crux of the project and are essential components associated with result generation.

Fig. 1: Block Diagram

A. ESP32 Dev kit module

ESP32-WROOM-32 is a powerful module that has Bluetooth and Wi-Fi inbuilt with 30 pins with a frequency of 2.4Ghz .It provides various interfaces including I2C,SPI ,UART. Its application involves music player,mp3 player encoding .It works at a voltage range of 3.7-5v, and its manufacturer is Espressif. It has a static ram of 512kb and works at a variable clock frequency of 80,160,240 MHz .

The chip has a low-power processor that can be used instead of the CPU(Central Processing Unit) to save power and energy while performing tasks that do not require much computational power, such as monitoring of peripherals. ESP32 integrates a set of peripherals, ranging from capacitive sensors to SD card interface, Ethernet, high- speed SPI, UART, I²S and I²C. The current while sleeping of the ESP32 module chip is less than 5 µA, making it suitable for battery wearable electronics applications.ESP32 is dual core with efficient power dissipating power which supports a data rate of up to 150 Mbps, 20 dBm power at the output to ensure the widest range

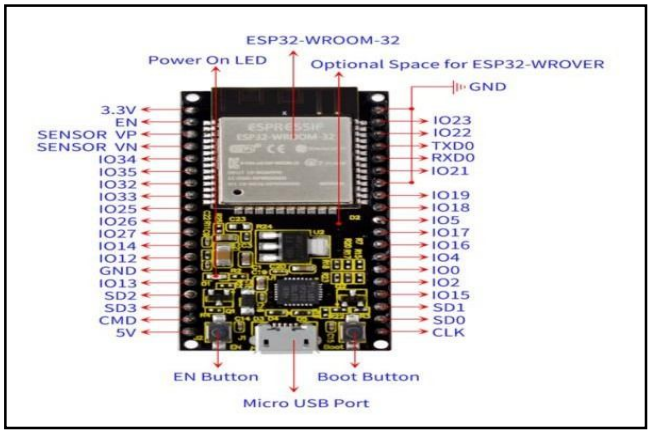

Fig. 2: ESP32 Module

B. Voltage Sensor

Voltage Sensor is a three-pin sensor for measuring voltage. It is based on principle of resistive voltage divider design. It makes the terminal connector input voltage to less than 5 times. It is allocated at a pin of 33 during its connectivity with esp32. The module is quite simple and very useful that is based on potential divider mechanism to reduce any input voltage bya factor of 5.

This ensures us to use the input pin corresponding to analog of the microcontroller to monitor voltages that is higher than the specified limit for sensing .Its maximum limit is 25v .

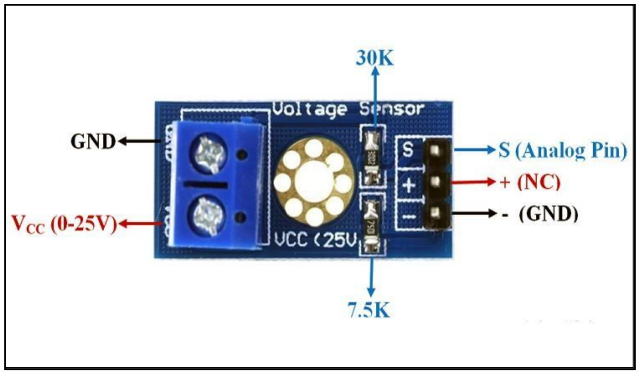

Fig. 3: Voltage Sensor

C. Speed Sensor Module

The Speed Sensor Module is a Groove Coupler for Arduino. The output pin which can be digital, or analog can be directly connected to a micro-controller Input port. It can detect the speed in terms of revolutions in a windmill based on the number of turns it makes in a minute .

This module can be connected to the relay, limit switch, buzzer module and can be integrated with an alarm as well to provide details in the form of 0 or 1 when output is obtained.

It acts as rpm(revolution per minute) counter whenever the motor rotates and makes one complete revolution. It is used in speed detection in motors, counting pulses ,determining the revolutions in sixty seconds and the position limit as well. It has a driving ability of more than 15mA. Makes use of the LM393 Voltage Comparator.

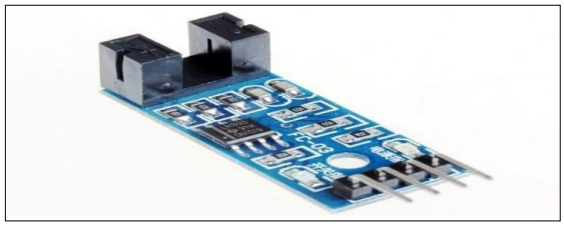
Fig. 4: Speed Sensor Module

D. GPS Module (Ublox NEO-6M)

The GPS module model is the Ublox NEO- 6M. This module makes use of the latest technology to determine the position of an object with the help of satellites and is composed of a 25 x 25mm active GPS antenna. For obtaining GPS lock at a fast rate a battery is also provided along with a socket of UART TTL.

The GPS module RX pin is connected at pin 16 whereas the TX pin to 17th pin of the ESP32 module for transmission and reception of the data that would be obtained by the satellites GPS module has four pins which are rx,tx, vcc and ground.

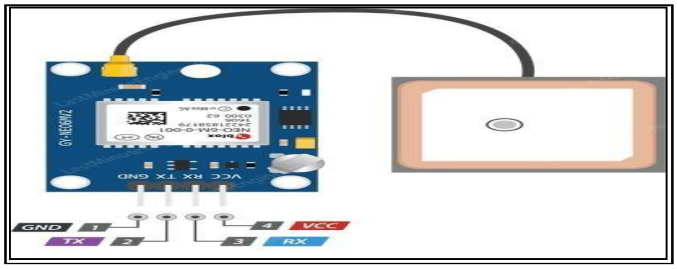

Fig. 5: GPS Module

E. DHT11 Sensor Module

DHT11 module can measure temperature and humidity with great precision . It can be easily connected and interfaced with Arduino, raspberry pi or any microcontroller for that purpose. It is interfaced with ESP32 on pin number 27 to obtain values of temperature along with humidity. DHT11 sensor consists of a thermistor for determination of temperature and is quite sensitive in nature and need not be soldered as well.

The DHT sensor can measure temperature and humidity at a great precision rate. It is quite cheap as well and easily available Can be mounted easily on breadboard and has 4 pins one for output, one for power supply ,one for ground and one pin is not connected. The sensor has four pins- vcc ,ground ,data Pin and a not connected pin.

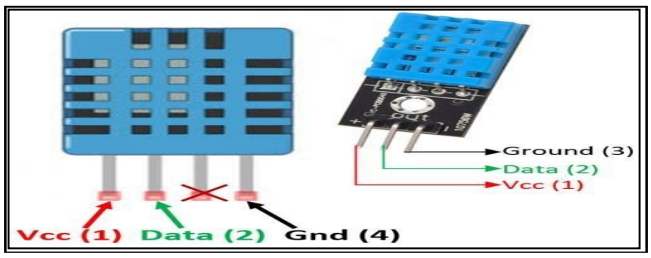

Fig. 6: DHT11 Sensor

F. Current Sensor (ACS712) Module

The ACS712 Current Sensor Module has a limit up to 20A. It is quite essential to ensure there is no overflow of current in any device that can cause damage to the complete circuit. It makes its applications in switch mode power supplies, wattmeter's and battery charging module to ensure current flows in one direction.

The current sensor module can detect AC as well as DC current with great efficiency. The out pin is connected at 33 pin of the ESP32 microcontroller to obtain value of the current.

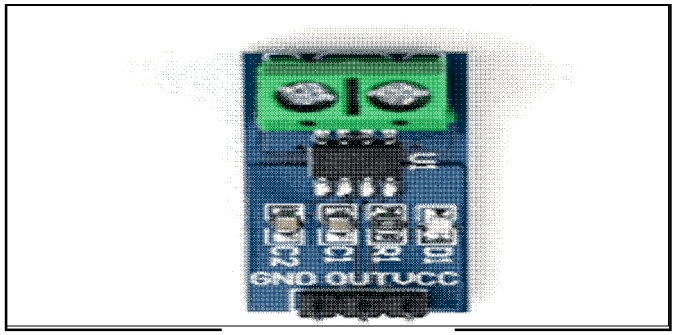

Fig. 7: Current Sensor Module

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G. BMP280 Module

BMP280 sensor is a cheap sensor that can determine temperature, pressure and altitude at a great level of efficiency and reliability. The other versions include BMP180,BMP390.The sensor is well accustomed to all weather conditions and can has two modes of operation which is inter integrated circuit and serial peripheral interface.

It can work as an altimeter as well when there are pressure changes. It can operate in both I2C as well as SPI . The sensor needs to be provided with an address while communicating its data in I2C peripheral interface

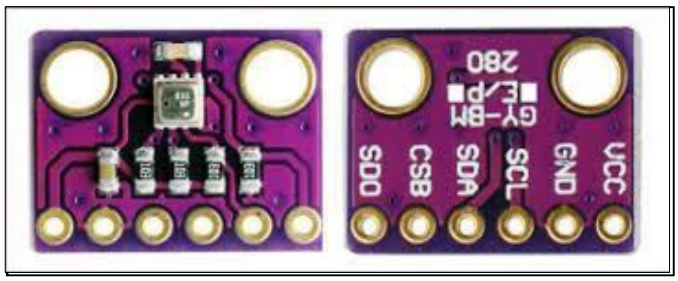

Fig. 8: BMP280 Module

V. SOFTWARE REQUIREMENTS

Table 1: Software Required

Names	Details
Firebase	Acts as real time database.
HTML, JavaScript, Bootstrap & Css	Used for developing Dynamic Webpage.
Arduino IDE	Assembly Language Programming.

VI. IMPLEMENTATION

Below is the circuit diagram that consists of all the sensors interfaced to ESP32 microcontroller. The data obtained from the sensors in real time would be sent to ESP32 for processing. The sensors are set at a baud rate of 9600 and the values are observed on the serial monitor.

In the circuit diagram ESP32 acts as the main microcontroller which accepts the data from dht11, voltage,current,bmp280,gps module and finally we can observe those values on the serial monitor at a baud rate of 9600 that is set. For the BMP280 sensors I2C mode is used, and the set of these sensors are set at an address of 0x76 and 0xF6.

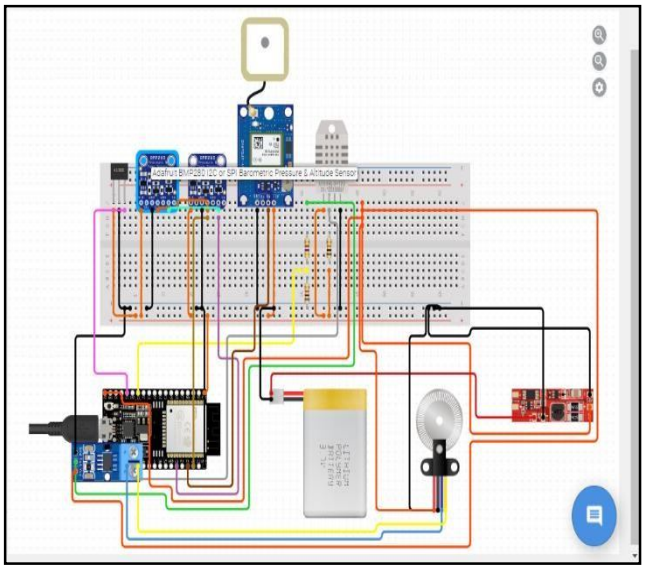

Fig. 9: Circuit Diagram

VII. RESULTS

The values and results obtained from the combination of sensors which are stored in real time in the Firebase which acts as a data store. Each set of values would come after an interval of 10 minuteswith a distinct API associated with it.

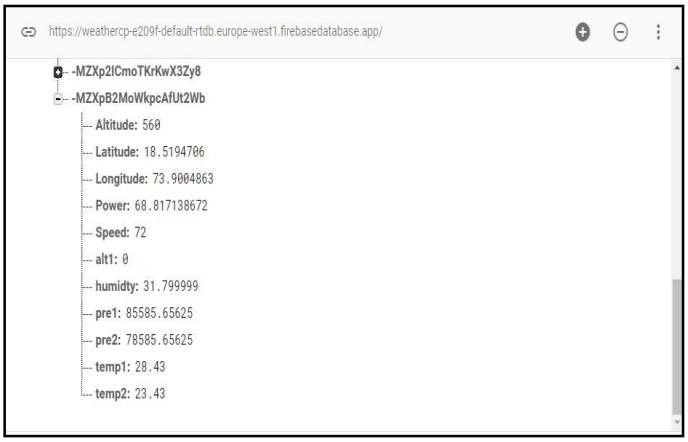

Fig. 10: Firebase

Dashboard showing the real time parameters of the wind turbine which can be accessed from anywhere. The dashboard portrays values in a time stamp of 5 intervals along with a mapper to see the optimal conditions. Real time data is visualized here in the form of graphs and donuts.

Also, a page with a button for calculating average power for 5 days and power over a day range along with a caution that acts as a limiter. A chat-bot for service support and maintenance can be seen in the right hand (down) corner. The latitude and longitude of the windmill can also be seen which is integrated with google maps.

A service alert page is there as well where the client can raise his issues whenever faced which would be stored in the firebase.

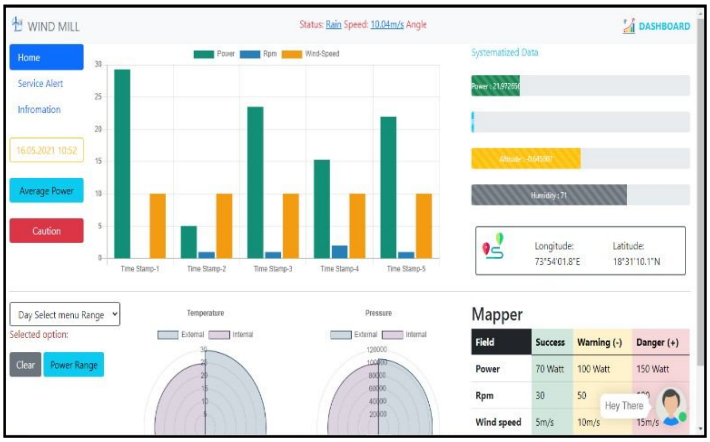

Fig. 11: Dashboard

VIII. CONCLUSION

A. Thus, the project was implemented starting with collection of data from the sensors to processing of it by ESP32.From there sending to Firebase for storage and visualizing it through dashboard. This dashboard is pubic for everyone and cost to implement it is as well moderate.

B. It can be used by agencies and companies to ensure that optimum conditions as well as servicing and maintenance of windmill is done for which an integrated chat-bot that books an appointment and service alert page in which users can list their issues.

C. Overall, it is a model that can be beneficial for wind farms and small-scale companies that need to maximize their reliability and efficiency in maintaining and servicing windmills based on information provided by the client on the dashboard that would be stored in the firebase.

D. Ensure that goods and the inventory exhaustation do not take place which could lead to disapproval and resentment from client side and in providing the service and supplies.
E. Make sure that optimal power generated by the windmills reach the farms and plants without any delay or issue
F. At all times implement techniques to obtain maximum power generation from the windmills .
G. Get insights and notifications from the dashboard in case of any issues or alert condition arise.
H. Analyze the downtime and reason for it to ensure it happens less frequent soon and service can be provided to the clients efficiently

IX. COMPLEXITIES INVOLVED

A. Storing power in sensing devices in unfavorableclimatic conditions.
B. Data format sending in Firebase.
C. Web Page Design.
D. Configuring the two BMP280 sensors together in I2Cmode.
E. GPS module transmission and reception.
F. Configuring all the sensors at the same baud rate anddelay.

X. ACKNOWLEDGEMENT

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We express our gratitude to our Head of School, ECE, Dr Vinaya Gohokar for always helping us and being there when we needed her help the most. It is because of her that we are presenting the project on the topic “Wind Turbine Parameters Estimation and Visualization Through Dashboard” at our department premises. We would also like to thank Prof. Vishal Mamde, Project Coordinator for his support and mentoring us throughout the course of this study. We really appreciate his help and concern and at the same time motivating us to get the most out of us.

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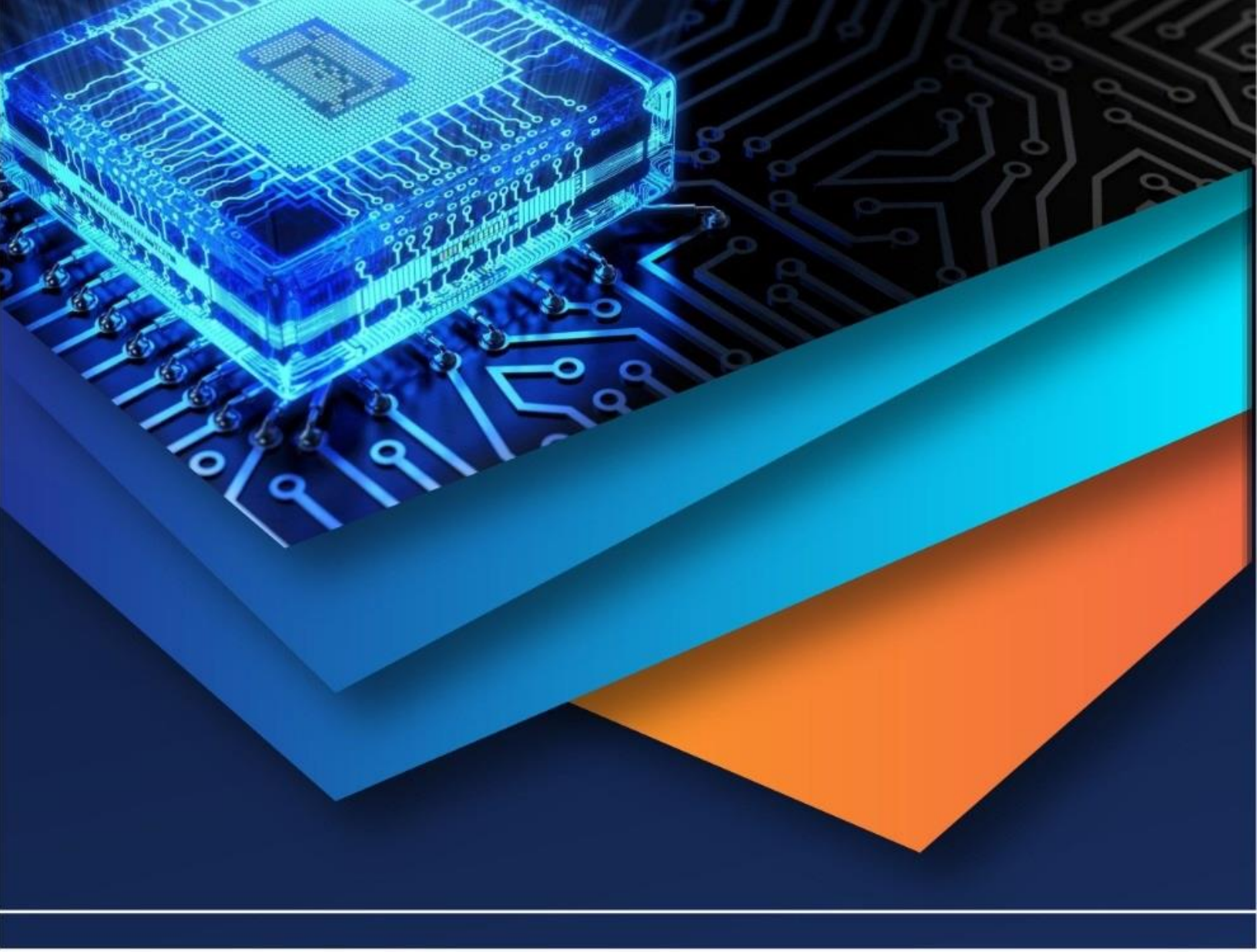

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