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Design and Develop Transformer Monitoring System using NODE-MCU and Real Time IOT Platform Connected using NODE-RED

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Abstract: ***In power system network, the most preferable electrical equipment for supplying power from the generating station to the consumers with the help of transmission lines is a transformer. It assists mankind with its long time service when operated under its rated conditions. Overloading and excessive cooling is the major cause of collapsing the transformer. Thus, to protect the transformer from these factors, a real-time monitoring system is required so that all the operating parameters like oil level, load current, winding temperature and voltage output can be taken care of. To maintain the reliability in grid operation it is important to monitor real time transformer health. In the proposed paper the main purpose is to get the real time figures about transformer remotely under the aegis of IOT. This application can be performed with the help of one current sensor (I), one voltage sensor (V), one temperature-humidity sensor (T-H) and one IR sensor. These sensors read analog values from the equipment's and for this reason it is connected to microcontroller through an ADC (analog to digital converter). The collected data will be sent using Wi-Fi module also it can be accessible from anywhere in the globe using IOT technology as well as HTTP protocol. This real-time transformer health monitoring system has greater reliability and significant cost saving also it helps to identify the scenario before causing any serious failure.***

Keywords: IOT, Node-Mcu, Node-Red, Microcontroller, Real-Time Transformer Monitoring System.

I. INTRODUCTION

Transformer acts as a vital role in power system. In any power system network, the transformer is an essential utensil which is used to distribute power through transmission line to the low voltage user one directly. But, their life is gradually reduced when subjected to overloading and voltage unbalance for a long time [1].Thus, the working condition of a distribution transformer plays an important role in distribution network and so must be run under rated conditions. Monika Agarwal et al. [10] designed a system using a transformer, microcontroller, logic level converter and GSM (Global System for Mobile Communication Modem), which shows the interaction between operator and the system. This GSM modem keeps track of the transformer health and sends message to the system. The low oil level and very high winding temperature result in voltage fluctuation which ultimately results in insulation failure and overall breakdown of the system. Supervisory Control and Data Acquisition (SCADA) is generally employed by some power companies for proper online monitoring of Power Transformers. However, amplification of this system for is quite costly [2]-[5]. Reference [11] shows a research using GSM technology was made, but it was not reliable and cheap. In earlier days, distribution transformers were monitored by a person who physically visited the site to take a note of the transformer parameters like incidental overload and overheating of the oil and windings and incidental overload. If they are not taken care of, they can decrease the transformer life. Pathak A.K, et al. [3] designed and implemented a mobile embedded system and recorded the key parameters of a distribution transformer such as load current, oil level and ambient modem, with a standalone single chip microcontroller and other sensors. A single parameter of the transformer is easily detected and monitored, but multiple parameters cannot be recognized easily and a lot of time is needed for operating the parameters. Moreover, all the useful data of the transformer becomes difficult to be monitored. Anirudh et el. [8] proposed an advanced remote monitoring system for distribution transformers, with easy installation and utilization, that used internet communication network to reduce the investment and operating cost. The installation and use of this system is also easy. A novel software, named DTMAS was introduced, for analysis of the voltage unbalance conditions [8]. Nowadays, to detect any kind of fault, online monitoring is done using the IOT technology [11]-[13]. In the proposed paper the design and implementation of an IOT embedded system to measure the load current, over voltage, transformer oil level and oil temperature is presented. This system is based on embedded system since microcontroller is used. In IOT, interaction between the physical and digital world is carried out using actuators and sensors. A sensor or a network of sensors is used to sense the physical parameters of the environment.

These processed sensor outputs are then sent to the main server or cloud with the help of various network devices. The various data obtained can be accessed over internet from anywhere around the world. This system is used to spot out the issues of the system before any objectionable failure, thus providing a long-life to the transformers. Hence IOT based monitoring of the voltage, current and temperature is more advantageous over manual monitoring. This technology helps to identify the faults before occurrence of a serious failure.

II. METHODOLOGY

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A. Existing System

In the past decades, to protect the electrical power system circuit breaker, fuse, and relays were used. However, when a fault occurs in a transformer in a remote area, it becomes unnoticeable. If the transformers are operated without the parameter value becomes difficult to be monitored, which leads to its breakdown and its lifetime is reduced.

B. Proposed System

The proposed system can spot the faults while fluctuating the input and output voltage, current, high winding temperature, oil level, etc, and by sensing this, the transformer under fault can isolate itself from the source. This wireless system easily communicates with the faulty transformer by obtaining its location using server.

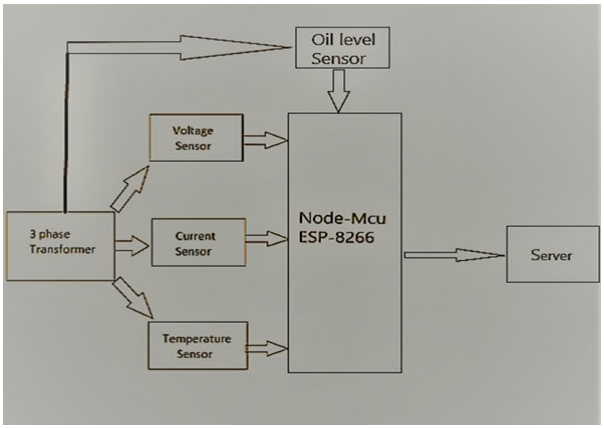
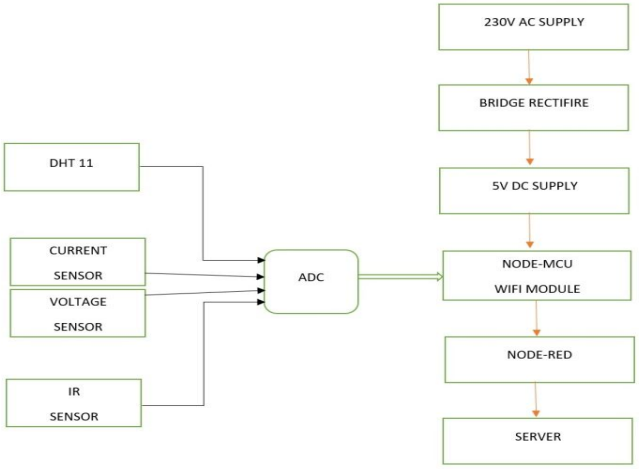


Fig. 1 Basic Structure of Proposed System

III.MAIN BLOCK DIAGRAM

This real-time system has been placed for monitoring the transformer parameters and can show the utilitarian information regarding transformer. The connected sensors are used due to monitoring the transformer. To sense the voltage of transformer voltage sensor is used, same as to sense the current, temperature and oil level of current sensor, temperature sensor and IR sensor is employed in this presented system.



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IV. HARDWARE IMPLEMENTATION IN THE PRESENTED SYSTEM

A. Voltage Sensor

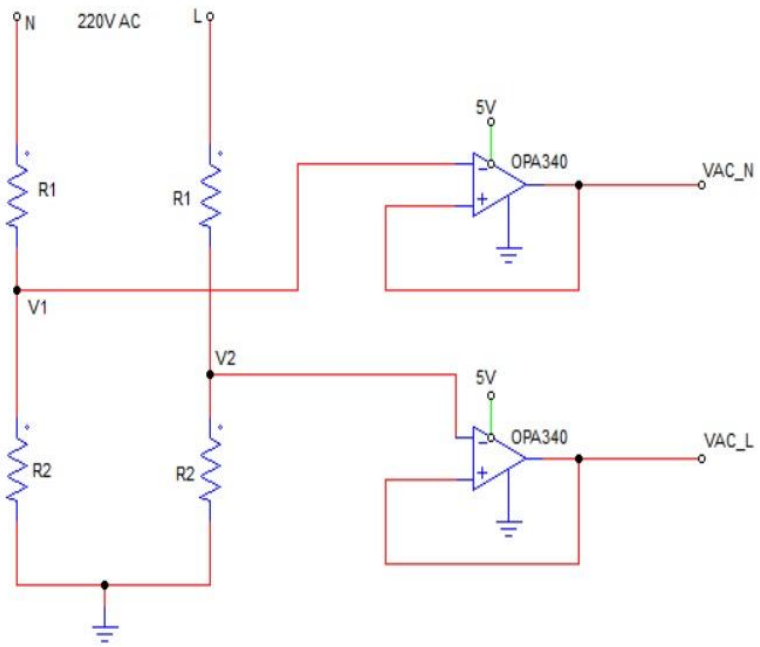

Fig. 2 Basic Circuit diagram of Voltage Sensor

The amount of voltage calculation and monitoring in an object is performed by a voltage sensor. AC and DC both voltages can be measured with the use of voltage sensor. In a voltage sensor the input should be voltage itself but, in the output, it returns either analog voltage signal, a current signal, or an audible signal and so on. The measurement through voltage sensor is derived from voltage divider. In the proposed system input supply of the sensor is 220V. As the node-mcu operates in 5V or 3V so, the input voltage is used to step down to 5V. An ADC (analog to digital converter) is adopted for rectification of the analog signal to a digital signal. A voltage regulator should be introduced to regulate the voltage at constant 5V supply, so that the microcontroller reads the value of the transformer.

B. Temperature and Humidity Sensor

The temperature and humidity sensor used here is DHT11. It is used to sense the current temperature status of the transformer. It may vary from simple ON/OFF thermostatic devices and generates calibrated digital output. It can measure the hotness or even coldness that is generated by the object or system so that any physical change can be detected by the external environment, thus producing a digital output on the data pin. DHT11 is a low cost and reliable sensor with long term stability. In the proposed system this sensor is used to measure the temperature and humidity of the transformer and send back the data to the operator. The DHT11 has 3 pins, one is connected to the ground, one is connected with the grid transmission line and the third one is for receiving data from the transformer. Node-red dashboard is showing the real time voltage and humidity of the transformer as shown in the screen also it displays the voltage graph of the whole day, week or year. If temperature of transformer is increases rapidly it sends signal to the dashboard of node-red.

C. IR Sensor

It is an electronics device that senses the light of surrounding objects. The IR sensor can detect and measure both the heat emits from the body as well as motion of that body. Actually, the thermal propagation is detected by IR sensor. Due to prolonged wavelength than visible light the IR sensor can't be detect. The IR sensor has two transmitting part one is transmitter and another one is receiver. It has also a proximity sensor to detect the objects. It is very easy to handle and very cheaper. In this monitoring system this IR sensor is placed to determine the oil level of the transformer. Whether the oil level is gone down the sensor received the data and send it via HTTP protocol and display the output in the dashboard of node-red.

D. Current Sensor

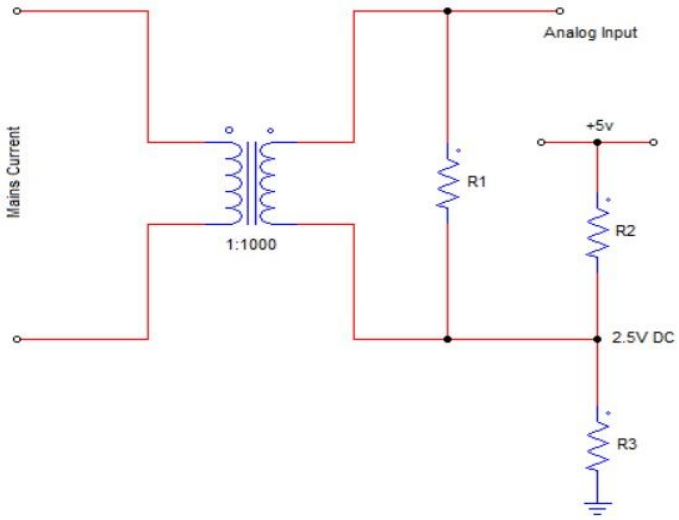

Fig. 3 Basic Circuit diagram of Current Sensor

The current sensor used is ACS712. It uses Indirect Sensing method for current evaluation. A magnetic field is generated when a current flows through the conduction path. This is sensed by a Hall Effect sensor. This sensor generates a voltage proportional to this sensed magnetic field, which then measures the current. This current sensor reads the real time current value of the transformer and gives feedback to the operator. A DC is connected with it, to convert the analog value to digital value which reads by node-mcu.

E. Node-Mcu

NODE-MCU is a low-cost open-source firmware platform which is very easy to use in IOT as a Wi-Fi module. There is basically two words in Node-Mcu, NODE and MCU, together act as a microcontroller unit. NODE-MCU as an IOT platform which connect the objects through Wi-Fi protocol to transfer data which is based on ESP8266.The circuit board containing dual in line package along with a USB controller and a small board carrying MCU and antenna. Node-Mcu has a 4MB flash memory and 128 kb RAM to store data and execute program. In this presented paper it is use ESP 8266 as a Node-Mcu. ESP 8266 is acted as both Wi-Fi module as well as Ethernet. This enlargement board provides the ESP-12E module holding ESP8266 chip having 32-bit microprocessor which set-off at 80 to 160 MHz adaptable clock frequency. It has having 9600 baud rate. ESP 8266 has 17 GPIO pins such as I2C, I2S, UART, PWM but only 11 of them are use, the reason behind is the rest 6 pins are making use of flash memory chip.

Fig. 4 Node-Mcu (ESP 8266)

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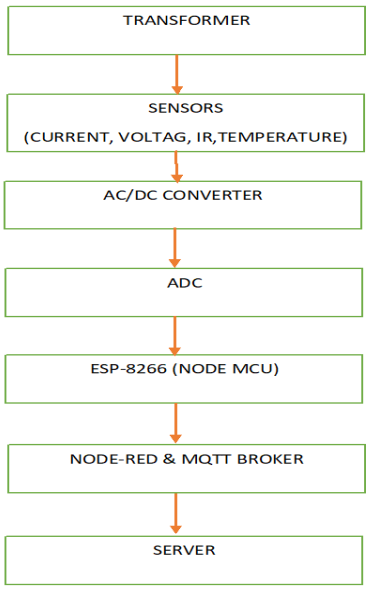
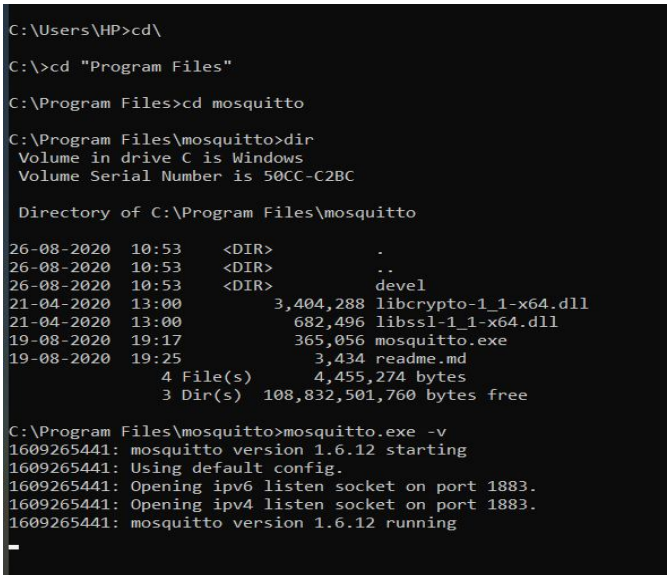
V. SOFTWARE IMPLEMENTATION

To operate this transformer monitoring system, it is very important to implement some software part. Here MQTT broker and Node-Red are introduced as a software part. The client is connected to the system through MQTT broker. The data collected from sensors are sent to the server through HTTP and TCP/IP protocol. The node-Mcu is Connected as a transmitter and receiver unit. The Node-Red is connected to local host network of the individual operator so it is very easy to connected with the Wi-Fi module and operate it individually.



A. MQTT Broker

The MQTT stands for Message Queuing Telemetry Protocol. The MQTT is a client server protocol. The design of MQTT is so simple, lightweight and it is easy to install. The MQTT is designed for low-bandwidth, high latency networks. For a person it is hard to understand the machine language so, this platform is implemented for communicate the system in machine-to-machine language (M2M). It is mandatory to have TCP/IP stack for both the broker and client so, MQTT protocol is barely dependent on TCP/IP. At a time, the MQTT connected between one client and one broker. The MQTT clients connects to a MQTT broker over a network and also it runs a MQTT library. Here for this proposed system Mosquitto is used as MQTT broker as its default version as shown in figure below. The MQTT features helps to send high volume sensor messages to the observer platform and different cloud stations.



B. Node Red

Node-red is an open-source visual editor used for visual programming that helps to rapidly inter-connect physical IO, cloud-based systems, data bases and most API's in any combination. Node-red is more and more used in growing world and in the field of IOT and IIOT. It is very flexible and powerful tool. It wires the hardware, API's and online applications in a fascinating way. In the node-red text editor mostly JavaScript functions are used. To save useful function there is a build-in library present in Node-Red. In this project the node-red is used as a server, also a platform where all the data will be visible which are reads by various sensors present in the operation. The MQTT broker helps node-red to connect with the sensors and receiving data from them. Any kind of changes in sensor is possible by programming the node-red. It is very easy to use and comparatively reliable to other platforms.

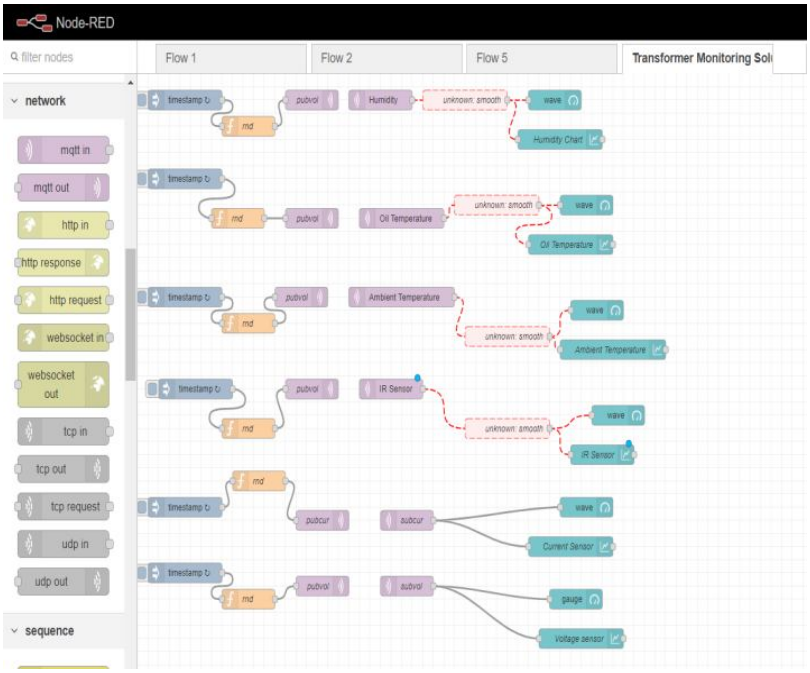


Fig. 5 Node-Red Interface

```
node-red
Microsoft Windows [Version 10.0.19042.685]
(c) 2020 Microsoft Corporation. All rights reserved.

C:\Users\HP>node-red
29 Dec 23:41:30 - [info]

Welcome to Node-RED
===================

29 Dec 23:41:30 - [info] Node-RED version: v1.1.3
29 Dec 23:41:30 - [info] Node.js  version: v12.18.3
29 Dec 23:41:30 - [info] Windows_NT 10.0.19042 x64 LE
29 Dec 23:41:35 - [info] Loading palette nodes
29 Dec 23:41:37 - [info] Dashboard version 2.23.2 started at /ui
29 Dec 23:41:37 - [info] Settings file  : \Users\HP\.node-red\settings.js
29 Dec 23:41:37 - [info] Context store  : 'default' [module=memory]
29 Dec 23:41:37 - [info] User directory : \Users\HP\.node-red
29 Dec 23:41:37 - [warn] Projects disabled : editorTheme.projects.enabled=false
29 Dec 23:41:37 - [info] Flows file     : \Users\HP\.node-red\flows_SAURAV-LAPTOP.json
29 Dec 23:41:37 - [info] Server now running at http://127.0.0.1:1880/
29 Dec 23:41:37 - [warn]

---------------------------------------------------------------------
Your flow credentials file is encrypted using a system-generated key.

If the system-generated key is lost for any reason, your credentials
file will not be recoverable, you will have to delete it and re-enter
your credentials.

You should set your own key using the 'credentialSecret' option in
your settings file. Node-RED will then re-encrypt your credentials
file using your chosen key the next time you deploy a change.
---------------------------------------------------------------------

29 Dec 23:41:37 - [info] Waiting for missing types to be registered:
29 Dec 23:41:37 - [info]  - smooth
```

VI. CONCLUSION

Monitoring manual transformer is not reliable these days, as it is not time efficient and also effects the smooth distribution. So the transformer monitoring process is performed using the IOT mechanism, as it is much efficient as compared to the manual one. It can monitor the oil level, temperature rise, ambient temperature and load current automatically by itself and can send alert to the authority for any fault in the system. This IOT comes with a NODE-RED interface that is link with the NODE-MCU with the help of HTTP protocol can be installed to this. By this process action will be immediate and catastrophic failure of power transformers can be prevented.

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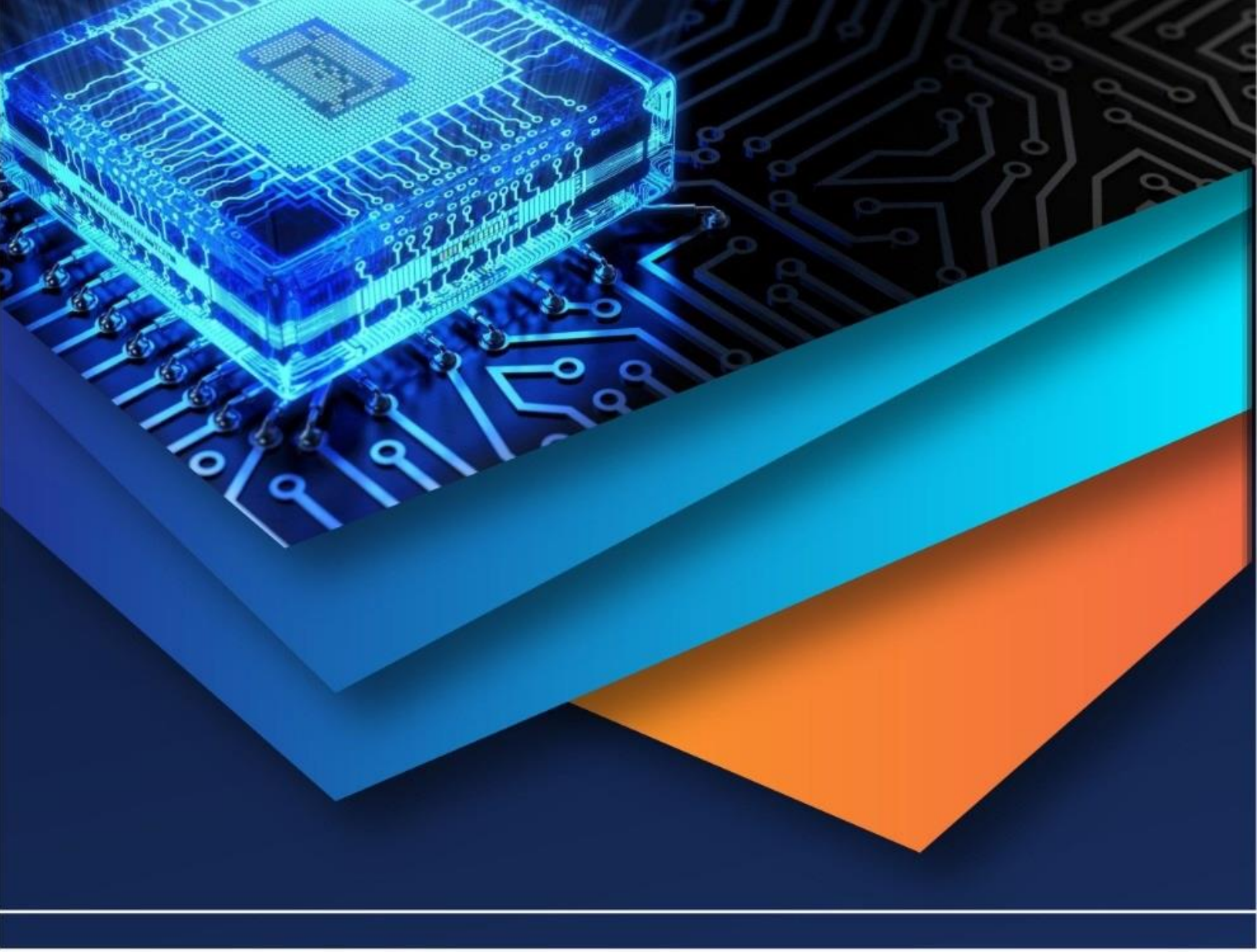

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