Transformer Fault Diagnosis and Resolving System

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***Abstract*— The system continuously monitors critical transformer parameters like temperature, current, voltage, and oil levels using sensors and an ESP32 microcontroller. It automatically activates corrective measures when abnormal readings are detected, such as controlling cooling mechanisms and triggering alerts. This project integrates IoT features for remote monitoring, providing a reliable solution for real-time transformer management and fault resolution. Future improvements could include expanding IoT capabilities for enhanced remote monitoring and control. This project offers a practical, cost-effective approach to ensuring transformer health and operational longevity in electrical distribution networks.**

I. Introduction

Power transformers are critical components of electrical distribution systems, enabling efficient power transmission over long distances. However, transformers are prone to faults such as overheating, overloading, and oil degradation, which can compromise their performance and lifespan. Continuous monitoring of transformers is essential to prevent catastrophic failures and optimize maintenance schedules. With advancements in Internet of Things (IoT) technologies, real-time monitoring systems can now be implemented cost-effectively using microcontrollers like the ESP32. This project proposes the development of a Transformer Fault Diagnosis and Resolving System that integrates multiple sensors to monitor temperature, current, voltage, and oil levels, providing both automated responses to faults and remote monitoring capabilities

II. Literature Review

Transformer monitoring systems are critical for ensuring the reliability and efficiency of power delivery systems. Recent advances in IoT, GSM, and machine learning technologies have revolutionized these systems. This review synthesizes key findings from research studies to highlight trends, innovations, and future directions.

Ravindran V. [1] presented a comprehensive IoT-based transformer monitoring system employing Raspberry Pi. The system provided real-time data on transformer parameters such as temperature and load, ensuring timely alerts for preventive maintenance. Similarly, Kumaresan J. and Mowlitharan N. [4] developed an IoT-driven platform for monitoring and controlling power transformers. Their system showcased scalability and adaptability to diverse grid requirements, emphasizing fault diagnosis and parameter visualization.

Guoshi Wang [5] introduced an IoT-enabled fault diagnosis framework for power transformers, focusing on data-driven insights to enhance fault detection accuracy. The study underlined the significance of integrating IoT technologies for predictive maintenance and improving grid reliability.

Ahmad Imtiyaz [9] combined IoT edge computing with machine learning to monitor transformer health. Their model enabled localized decision-making, reducing latency and dependency on centralized data processing.

Rahman S. [2] explored a GSM-based transformer health monitoring solution. By transmitting transformer parameters via SMS, the system catered to regions with limited internet connectivity. Though cost-effective, this approach faced challenges in scalability and real-time responsiveness compared to IoT-based systems.

Singh J. and Aggarwal S. [3] investigated transformer monitoring within India's evolving smart grid landscape. Their work highlighted the necessity of integrating real-time monitoring with grid communication protocols, promoting energy efficiency and fault prevention.

Muhammad Kashif [8] extended this perspective by addressing fault detection and protection within smart grids. Using IoT frameworks, the study improved system resilience, paving the way for adaptive protection strategies.

Zhu Y. and colleagues [7] applied ultrasonic sensors for monitoring transformer oil levels. This innovative method showcased the potential of non-invasive techniques for maintaining transformer health, ensuring prolonged equipment life and reliability.

Abubakar S. I. and colleagues [6] proposed an ESP32-based IoT platform for smart home automation, demonstrating how adaptable IoT frameworks can be repurposed for transformer monitoring. The study emphasized cost-efficiency and modular design.

These studies collectively demonstrate significant strides in transformer monitoring through IoT, machine learning, and communication technologies. While IoT-based systems offer advanced features like predictive maintenance and real-time analysis, GSM-based solutions remain relevant for low-connectivity regions. Future research should focus on hybrid models combining IoT and edge computing for enhanced efficiency and adaptability in diverse power systems.

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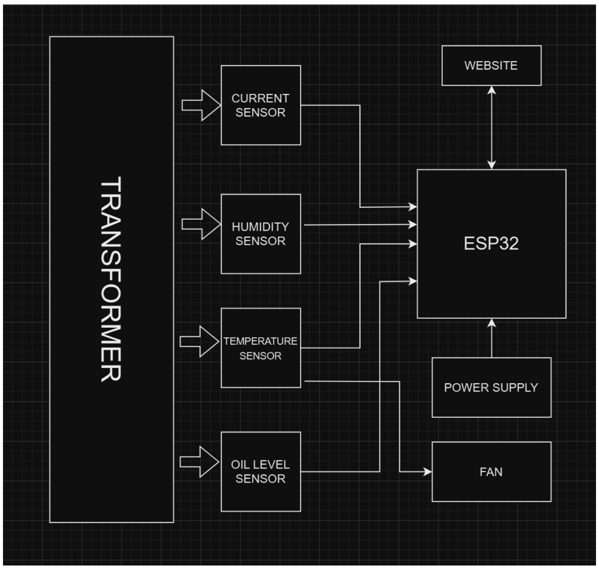
III. Overall system and its components

BLOCK-DIAGRAM:



Key Components:

ESP32 Microcontroller: The central processing unit responsible for data acquisition from sensors, decision-making based on predefined thresholds, and control of relay outputs for fault resolution.

DHT11 Temperature and Humidity Sensor: Measures the temperature and humidity of the transformer and triggers the cooling fan when the temperature exceeds a specified threshold.

ACS712 5A Current Sensor: Monitors the current flowing through the transformer, detecting overloads or underloads, and provides real-time current readings.

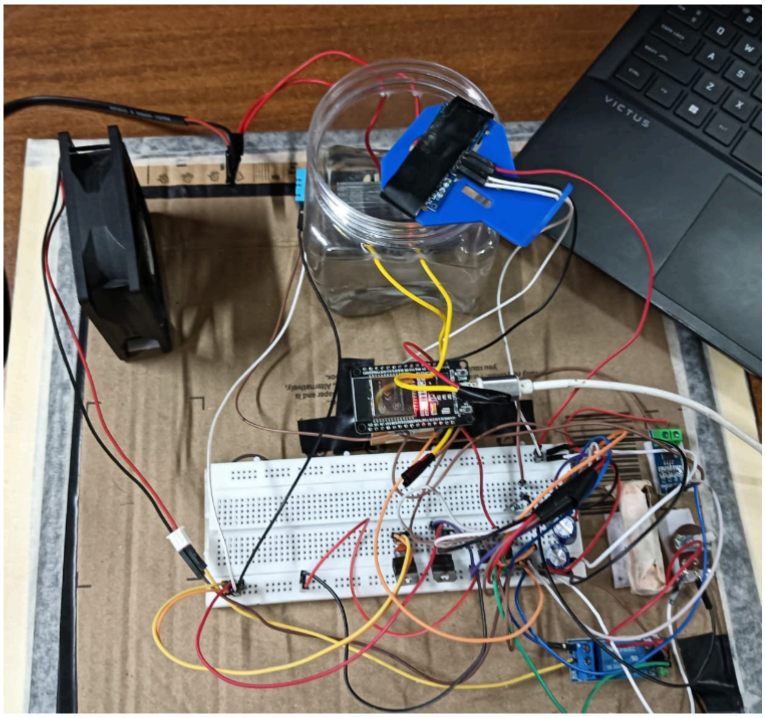
Ultrasonic Sensor: Monitors the oil level within the transformer, alerting users when the oil level falls below a predefined threshold.

Relay Module (JQC3F-05VDC-C): Controls the cooling fan based on temperature readings. It activates when the temperature exceeds the threshold, helping to prevent overheating.

Wi-Fi Connectivity: Utilizes the ESP32's built-in Wi-Fi capabilities to send alerts when critical thresholds are breached, enabling remote monitoring of the system.

10K Potentiometer in series with 470 ohm resistance to vary current.

IV. Hardware implementation



Picture of the prototype model

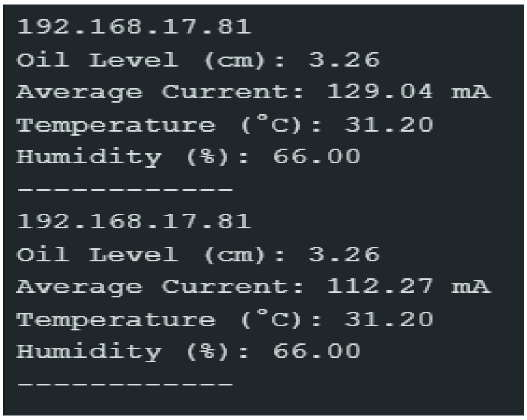
The ESP32 microcontroller serves as the central hub, connecting all the components. The DHT11 temperature sensor is placed on the transformer and connected to GPIO 25 of the ESP32 to continuously monitor the transformer's temperature. The ultrasonic sensor is positioned above the oil tank to measure the oil level, and it is connected to GPIO 5(trigger) and 18(echo).

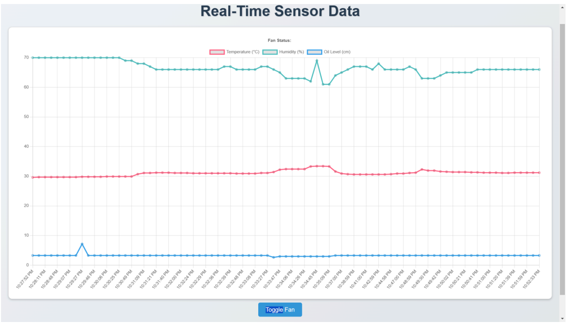
For electrical parameter monitoring, the ACS712 current sensor is also connected, both monitoring real-time current and voltage levels. A 470 ohm serves as the load for the current and voltage sensors which is connected with a potentiometer which is used for varying the current for demonstration purposes.

The relay module is connected to GPIO 26 of the ESP32 and controls the cooling fan, which activates automatically when the DHT11 detects that the temperature has exceeded a predefined threshold. We have used a battery connected in series with relay to make the effective voltage for relay triggering 5v. DHT11 also monitors the humidity.

The system prototype is powered by an external power bank while the transformer is connected to the mains. The system sends data in real time to the website, which can be accessed remotely.

V. RESULTS AND DISCUSSIONS





Screenshots of data collected from the sensors and the website showing the graph.

Code:

https://github.com/Healer28/Transformer-Fault-Diagnosis-and-Resolving-System-

Oil level>5cm=>Warning triggered
Temperature>32C=>Warning triggered

We successfully implemented a system that monitors the transformer's temperature using a DHT11 sensor and controls a cooling fan via a relay when the temperature exceeds a certain threshold. The oil level in the transformer is also monitored using an ultrasonic sensor. All sensor data, including the temperature and oil level, are displayed in real-time on a web interface, with graphs for better visualization. Additionally, the current was varied using a potentiometer, with the resistor as the load, and the system successfully break the circuit through the relay when overcurrent and undervoltage conditions were detected.

VI. CONCLUSION

In conclusion, the Transformer Fault Diagnosis and Resolving System provides an effective and affordable solution for monitoring and managing the health of power transformers. Using an ESP32 microcontroller in combination with sensors for temperature, current, voltage, and oil levels, the system ensures real-time monitoring and automatic fault detection. In response to faults, corrective measures are automatically triggered, such as controlling the cooling fan to prevent overheating. The project also incorporates IoT capabilities, utilizing a website interface that allows users to remotely monitor and analyze key parameters of the transformer, adding an extra layer of convenience and accessibility.

This system demonstrates the successful integration of IoT for real-time monitoring while maintaining cost efficiency and ease of implementation. The project highlights the potential for future improvements, such as expanding the monitoring system's capabilities and refining its IoT functionalities. Overall, the system addresses key challenges in transformer maintenance, offering a practical and automated approach to enhancing operational safety and efficiency in power distribution networks.

ACKNOWLEDGMENT

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