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IOT Based Transformer Health Monitoring System

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Abstract: Distribution transformers play a crucial function in electric strength structures and their failure can lead to strength interruption and high upkeep prices continuous tracking of transformer fitness parameters is important to prevent sudden faults and enhance system reliability this task presents an iot-based transformer health monitoring machine that permits real-time remark of crucial parameters together with transformer temperature and oil stage the proposed machine makes use of a nodemcu esp8266 microcontroller to gather information from a temperature sensor and an ultrasonic sensor used for oil level monitoring the sensed statistics is displayed domestically on an lcd show and simultaneously transmitted to a cloud platform using wi-fi for faraway tracking when odd situations are detected an alert buzzer is activated and a cooling fan is robotically grew to become on to protect the transformer from harm the developed device reduces the want for guide inspection lets in early fault detection and gives a cost-powerful and green solution for transformer health monitoring the use of internet of things generation.

Keywords: IoT, Transformer Health Monitoring, NodeMCU ESP8266, **DHT11 Temperature Sensor**, **Ultrasonic Sensor**, Cloud Computing, Embedded Systems, Real-Time Monitoring.

I. INTRODUCTION

Electric power is a basic necessity in todays world as almost every activity depends on a stable electricity supply distribution transformers play a crucial role in delivering electrical energy from power stations to consumers by reducing voltage to suitable levels these transformers are widely installed in cities industries and commercial locations when a transformer operates improperly or fails it may cause serious power interruptions economic impact and inconvenience to users for this reason ensuring the healthy operation of distribution transformers is an important requirement in power distribution systems.

In most conventional systems transformer condition is evaluated through routine inspections carried out by maintenance personnel during these visits factors such as temperature rise and oil level are checked manually although this method has been in practice for many years it does not provide continuous supervision of transformer behavior faults like overheating or oil leakage can develop suddenly between inspection periods and remain unnoticed over time such unnoticed conditions may weaken transformer components and result in sudden breakdowns.

Advancements in communication and embedded technologies have opened new ways to improve equipment monitoring the internet of things iot makes it possible to connect sensors and controllers to the internet allowing operational data to be collected and accessed remotely by using iot-based systems electrical equipment can be monitored continuously without depending on frequent human involvement this helps in identifying abnormal conditions early and taking preventive measures before serious damage occurs.

This project presents the development of an iot-enabled transformer health monitoring system using a nodemcu esp8266 controller the system is designed to observe key transformer parameters such as temperature and oil level with the help of a dht11 temperature sensor and an ultrasonic sensor the sensed values are shown locally on an lcd unit and transmitted wirelessly to a cloud platform for remote observation if the system detects abnormal conditions a buzzer alert is generated and a cooling fan is activated automatically to protect the transformer the proposed solution is simple to implement economical and effective for continuous monitoring of transformer operating conditions.

1.2 LITERATURE REVIEW

Agarwal and pandya 2014 proposed a transformer monitoring system using gsm technology to overcome the limitations of manual inspection their system was able to send alert messages when abnormal conditions were detected although this method reduced human effort it provided only basic alerts and did not support continuous monitoring or online data access.

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Mao et al 2010 developed a remote monitoring system for distribution transformers using wireless communication the system collected transformer data and transmitted it to a control station which helped reduce the need for frequent site visits however the system required complex communication setup and involved higher costs making it less suitable for large-scale implementation.

Pathak et al 2016 introduced an embedded system to monitor transformer temperature and oil level using sensors when the values crossed safe limits warning messages were generated this approach improved fault detection compared to traditional methods but it was limited to message notifications and did not provide real-time data visualization or storage for future analysis with the growth of internet technologies researchers began using the internet of things for transformer monitoring.

Shastrimath et al 2018 designed an iot-based monitoring system that allowed continuous observation of transformer parameters using internet connectivity their work showed that iot systems can reduce maintenance effort and improve reliability by providing real-time access to data.

Kumar et al 2020 studied the use of iot and cloud platforms for monitoring electrical equipment in power systems their research highlighted that cloud-based monitoring allows data to be stored viewed and analyzed remotely helping in early fault detection and preventive maintenance.

II. PROBLEM STATEMENT

Distribution transformers are critical components in power distribution networks, supplying electricity to residential, commercial, and industrial consumers. Any failure in a transformer can lead to power interruptions, equipment damage, financial loss, and inconvenience to users. Hence, maintaining the healthy operation of distribution transformers is a major concern for power utilities.

In many existing systems, transformer condition monitoring is carried out through periodic manual inspections. Parameters such as temperature and oil level are checked by maintenance personnel at scheduled intervals. However, this approach has several limitations. It does not provide continuous monitoring, and sudden faults such as overheating or oil leakage may occur between inspections and remain undetected. These unnoticed abnormalities can gradually damage the transformer and may result in unexpected breakdowns.

Manual monitoring also requires significant human effort, time, and operational cost, especially when transformers are installed in remote or difficult-to-access locations. Moreover, the absence of real-time data makes it difficult to take timely preventive actions, increasing the risk of severe transformer failure and reduced system reliability.

Therefore, there is a need for an automated, real-time monitoring system that can continuously observe critical transformer parameters and provide immediate alerts during abnormal conditions. Such a system should minimize human involvement, enable remote access to transformer data, and support early fault detection. Addressing these challenges is essential to improve transformer reliability, reduce maintenance costs, and ensure uninterrupted power supply.

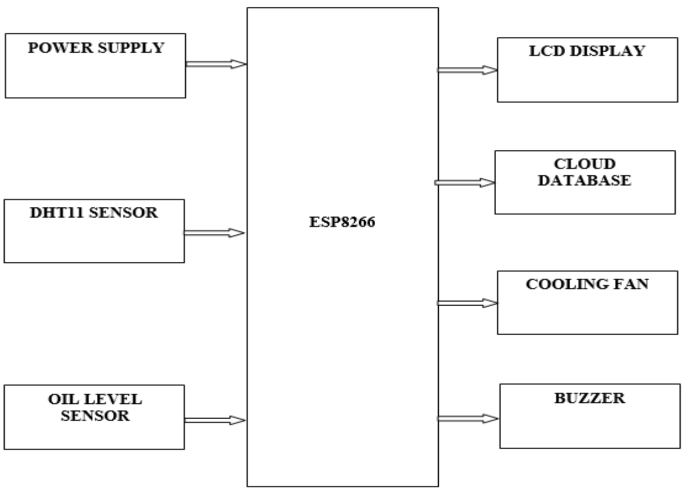

Figure 1: System Flow Diagram of IoT-based Transformer Health Monitoring System

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III. METHODOLOGY

The proposed IoT-based transformer health monitoring system is designed to continuously monitor transformer parameters and generate alerts when abnormal conditions occur. The system minimizes manual inspection and improves transformer safety. The methodology is divided into the following steps:

1. Hardware Setup
The hardware components required for the project include:

- NodeMCU (ESP8266) microcontroller
- DHT11 temperature sensor
- Ultrasonic sensor
- LCD display
- Buzzer
- Cooling fan

All components are properly assembled and connected. The **DHT11 sensor** measures the transformer temperature, while the **ultrasonic sensor** monitors the oil level inside the transformer tank. The LCD is used for local real-time display of these parameters.

2. Microcontroller Programming
The NodeMCU is programmed using the **Arduino IDE**. The program reads data from the sensors at regular intervals and compares the values against predefined safe limits. If the temperature or oil level goes beyond the safe range, it is considered an abnormal condition. This programming ensures continuous monitoring and real-time processing of sensor data.

3. Data Display
The measured transformer temperature and oil level are displayed on the **LCD screen**. This allows maintenance personnel to view the transformer's status locally. Displaying the readings in real time helps in quick identification of any abnormal condition at the transformer site.

4. Remote Monitoring
The sensor data is transmitted to a **cloud platform via Wi-Fi**, enabling remote monitoring from anywhere. This ensures that the transformer condition can be tracked even when personnel are not physically present. Remote monitoring also allows timely decision-making in case of any abnormality.

5. Alert System
If the measured parameters exceed the safe limits:

- A **buzzer** is activated to alert nearby personnel.
- In case of high temperature, the **cooling fan** automatically turns on to reduce the heat.
  Once the transformer parameters return to normal, the buzzer and fan are switched off automatically. This ensures continuous protection without wasting energy.

6. Summary
Through this methodology, the system achieves **real-time monitoring**, **automatic alerts**, and **remote observation**, which reduces manual effort and prevents unexpected transformer failures. It provides a reliable, cost-effective solution for transformer health monitoring.

IV. RESULTS AND DISCUSSION

The proposed IoT-based transformer health monitoring system was implemented and tested successfully. The system continuously monitored key parameters such as transformer temperature and oil level using appropriate sensors. Under normal conditions, the sensed values remained within safe limits and were clearly displayed on the LCD. The same data was also transmitted to the cloud platform, allowing remote monitoring in real time.

(LCD display showing transformer temperature and oil level under normal operating conditions)

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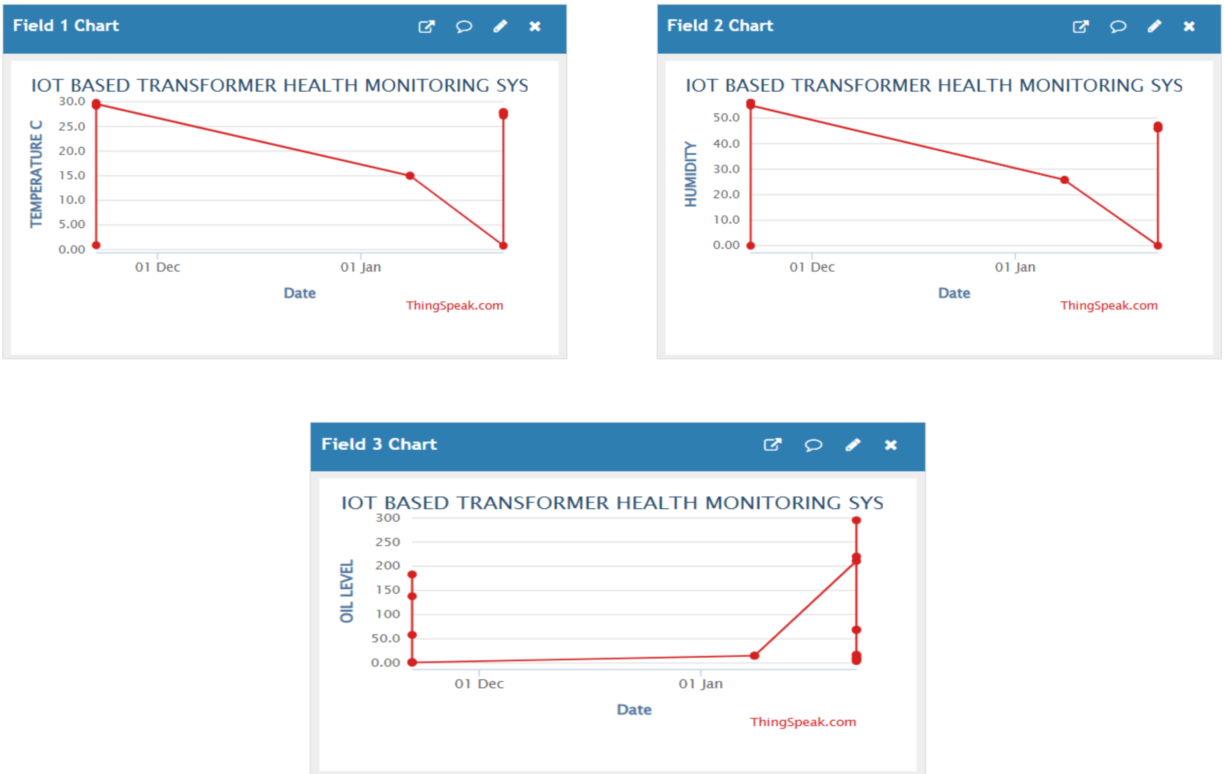
When the transformer temperature exceeded the predefined limit, the system responded immediately by activating the buzzer and switching on the cooling fan. This helped reduce the temperature and prevent overheating. Once the temperature returned to a normal range, the alert and cooling fan were automatically turned off. Similarly, a drop in oil level was detected accurately by the ultrasonic sensor, and an alert was generated to indicate a possible fault condition.



(Cloud dashboard showing transformer temperature, humidity and Oil Level readings over time)

The results show that the system is capable of detecting abnormal conditions at an early stage and providing timely alerts. Compared to traditional manual inspection methods, the proposed system improves monitoring efficiency, reduces human effort, and enhances transformer safety. Overall, the system performed reliably and demonstrated the effectiveness of IoT technology in transformer health monitoring.

V. CONCLUSION AND FUTURE WORK

The proposed system was tested under different conditions, and the results show that the protection mechanism works accurately and responds properly during abnormal and faulty situations. The system is highly sensitive to changes in transformer parameters, which helps in detecting problems at an early stage. Continuous transformer health monitoring makes it possible to identify unexpected conditions before they lead to serious failures. This improves system reliability and helps in reducing maintenance and replacement costs.

One of the major advantages of the proposed system is that transformer status can be monitored remotely from any location using internet connectivity. There is no need for continuous human supervision, as the system automatically tracks transformer conditions and updates the data to the cloud whenever an abnormal condition occurs. This reduces manual effort and ensures timely action during fault conditions.

VI. FUTURE SCOPE

In future, the system can be extended by adding more sensors such as voltage and current sensors to monitor additional transformer parameters. A centralized cloud database can be developed to store and analyze data from multiple transformers installed at different locations. Advanced data analysis techniques can also be integrated to predict faults in advance, making the system more reliable and suitable for large-scale power distribution networks.

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