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TRANSFORMER FAULT MONITORING AND AUTOMATION USING IoT

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Abstract: The main aim of this project is to detect transformer line faults and monitor the system in real time. The system uses ESP32, voltage sensor, relay, buzzer, LCD display, and IoT platforms like Blynk.The voltage values are continuously monitored and displayed on the LCD. The data is also sent to the loT platform for remote monitoring. When a fault occurs, the system gives an alert using a buzzer and automatically disconnects the supply using a relay. This helps to protect the transformer and reduce damage.This project provides a simple, low-cost, and effective solution for transformer monitoring and automation.

Keywords: Digital Relay, Transformer, Microcontroller, Fault Detection, Protection System

I. INTRODUCTION

The power transformer is one of the most important components in electrical power distribution systems. Any fault in transformer lines may cause power interruption, equipment damage, and safety problems. Therefore, continuous monitoring and protection of transformers are necessary to ensure reliable power supply.

Traditional transformer monitoring systems mainly depend on manual inspection and conventional protection devices, which are not efficient for real-time monitoring and quick fault detection. To overcome these limitations, Internet of Things (IoT) technology is introduced in modern monitoring systems.

This project, “Transformer Line Fault Monitoring and Automation Using IoT,” is designed to monitor three-phase line conditions and detect faults automatically using ESP32. The system continuously checks the voltage status of each phase and disconnects the supply during abnormal conditions using a relay circuit. The fault information is also sent to the Blynk IoT platform through Wi-Fi for remote monitoring and alert notification.

The proposed system improves transformer protection, reduces manual supervision, increases reliability, and provides a low-cost smart monitoring solution for power systems.

II. LITERATURE REVIEW

Many researchers have discussed transformer protection and monitoring systems using IoT and microcontroller technology. Several studies focused on real-time fault detection, voltage monitoring, and automatic protection of transformers using controllers such as Arduino and ESP32. Researchers like Muhammad H. Rashid, Simon Monk, and Raj Kamal explained the importance of power system protection, automation, and IoT communication in electrical monitoring applications.

State of Art: This literature review presents the commonly used techniques for transformer line fault monitoring and protection systems. Traditional transformer monitoring systems mainly use relays, circuit breakers, and manual

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inspection methods for fault detection. However, these methods do not provide real-time monitoring and remote access facilities.

Recent developments in IoT technology made it possible to monitor transformer conditions continuously using wireless communication and cloud platforms. ESP32-based systems provide efficient voltage monitoring, automatic fault detection, and remote alert notification through mobile applications such as Blynk IoT. Advances in digital technology, embedded systems, and wireless communication improve the reliability, safety, and efficiency of transformer protection systems. The proposed IoT-based monitoring system offers a low-cost and reliable solution for transformer line fault monitoring and automation.

III. EXISTING SYSTEM

The existing transformer protection system mainly depends on conventional protective devices such as fuses, circuit breakers, and electromechanical relays for fault detection and protection. In these systems, transformer conditions are monitored manually, and faults are identified only after abnormal conditions occur. Traditional systems do not provide real-time monitoring, remote access, or automatic alert notification facilities. Due to the absence of continuous monitoring, fault detection becomes slower and may lead to transformer damage, power interruption, and increased maintenance cost. These systems also require more manpower for supervision and maintenance, reducing the overall efficiency and reliability of the power distribution system.

IV. PROPOSED SYSTEM

The proposed system is an IoT-based transformer line fault monitoring and automation system designed using ESP32 microcontroller technology. The system continuously monitors the three-phase voltage conditions and detects faults automatically in real time. When any abnormal condition or phase failure occurs, the ESP32 controller activates the relay to disconnect the transformer supply and turns ON the buzzer for alert indication. The system also sends fault information and voltage status to the Blynk IoT platform through Wi-Fi, allowing remote monitoring using a mobile device. This proposed system improves transformer protection, reduces manual supervision, provides fast fault detection, and increases the reliability and efficiency of the power distribution system at a low implementation cost.

Advantages:

- Real-time monitoring
- Automatic fault detection
- Fast protection action
- Remate access
- Reduces manual work
- Improves safety

V. SYSTEM ARCHITECTURE

The system architecture of the proposed Transformer Fault Monitoring and Automation Using IoT consists of four main units: sensing unit, processing unit, communication unit, and actuation unit. In the sensing unit, voltage sensors are connected to all three phases (R, Y, and B) of the transformer to continuously measure voltage levels and detect any abnormalities such as overvoltage, undervoltage, or phase failure. These analog signals are then sent to the processing unit, where a microcontroller such as Arduino or ESP32 processes the data and compares it with predefined threshold values to identify fault conditions.

Once a fault is detected, the processing unit activates the communication unit, which uses an IoT module like ESP8266 or ESP32 Wi-Fi to send real-time data to a cloud platform or mobile application such as Blynk. This allows users to remotely monitor the transformer status and receive instant alerts. At the same time, the actuation unit consisting of a relay and buzzer is triggered.

The relay isolates the transformer from the supply to prevent damage, while the buzzer provides a local alarm indication.Overall, this architecture enables continuous monitoring, fast fault detection, and automatic protection, ensuring improved safety, reliability, and efficient operation of the transformer system.

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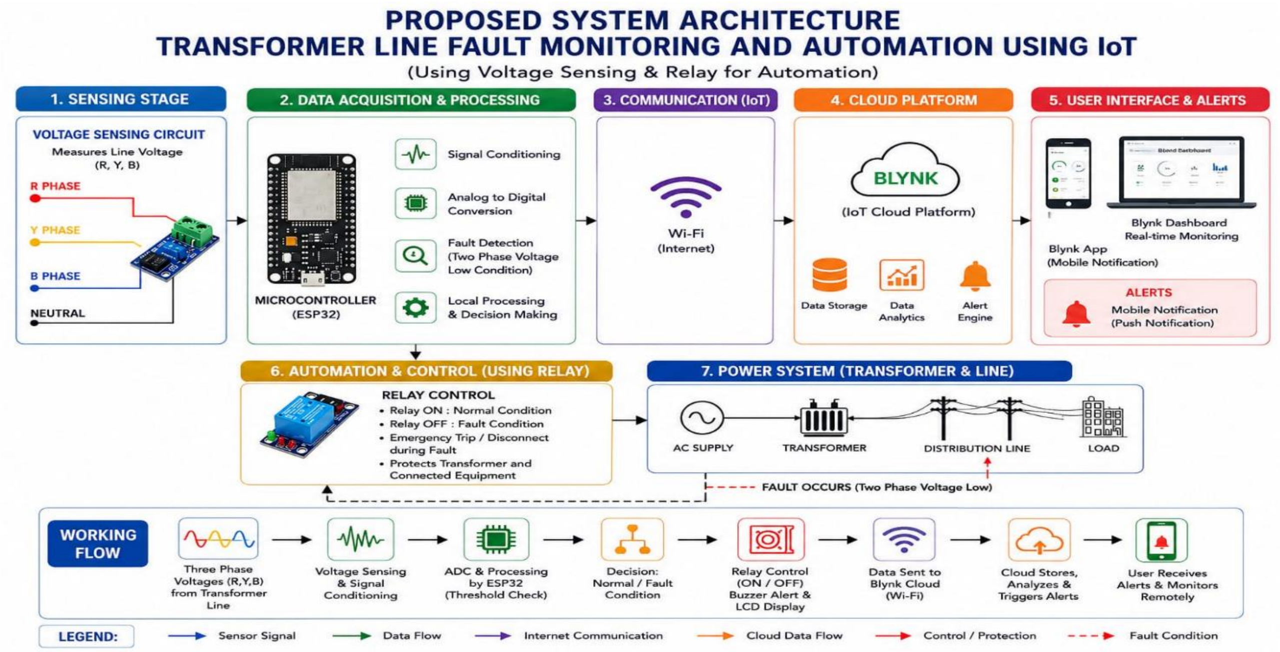

Fig. 1 System Architecture of Transformer fault monitoring and automation using IoT

Data Flow Architecture:

The data flow architecture of the system starts with voltage sensors that continuously measure the three-phase (R, Y, B) transformer voltages. These signals are sent to a microcontroller (Arduino/ESP32), where the data is processed and compared with predefined threshold values to detect faults. If the system is normal, the data is transmitted to the IoT cloud for real-time monitoring on a mobile application.

When a fault is detected, the microcontroller immediately sends an alert to the IoT app and simultaneously activates the relay to disconnect the transformer from the supply. A buzzer is also triggered for local warning. This ensures fast fault detection, remote monitoring, and automatic protection of the transformer system.

HARDWARE COMPONENTS:

A. Microcontroller(Arduino UNO):
Main control unit that processes sensor data and controls the system.

B. Voltage sensors:
Used to measure 3-phase (R, Y, B) transformer voltages for fault detection.

C. ESP8266 Wi-Fi Module:
ESP8266 is a Wi-Fi-enabled microcontroller based on the ESP8266 module. It is used for sensor interfacing, data processing, and IoT communication.

Features:

- Built-in Wi-Fi module.
- Low power consumption.
- Easy programming using Arduino IDE.
- Supports IoT applications.

D. Buzzer:
The buzzer generates alerts during abnormal operating conditions.

E. Relay Module:
Automatically disconnects the transformer during fault conditions for protection.

F. LCD Display
The LCD display shows real-time parameter values such as temperature ,voltage and current level.

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G. 3-Phase Input Supply:

Provides input for monitoring transformer conditions.

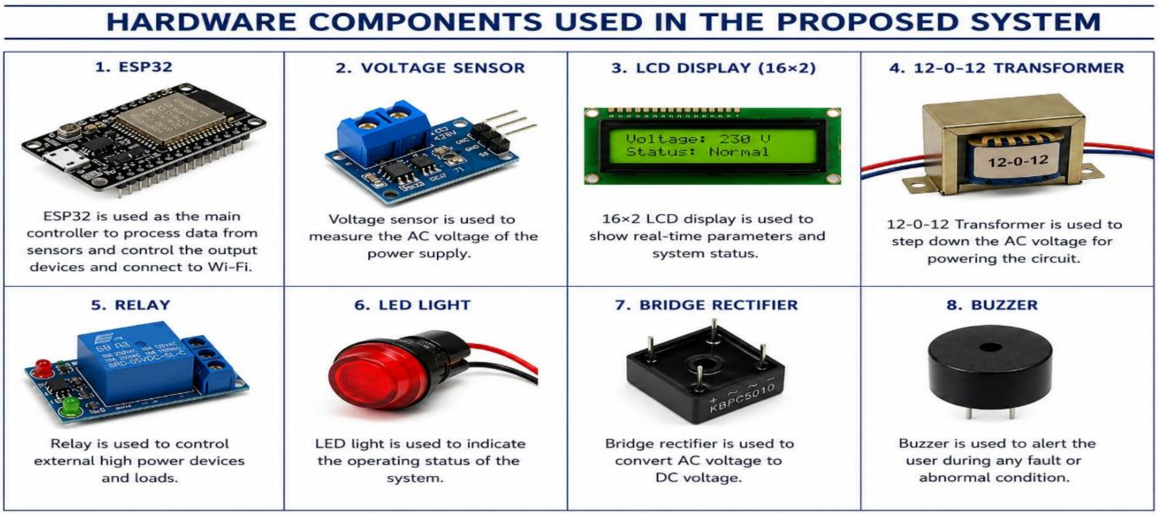

Fig. 2 Hardware Components Used in the Proposed System

VI. WORKING PRINCIPLE

The working principle of the Transformer Fault Monitoring and Automation Using IoT is based on continuous monitoring of three-phase voltage and automatic fault response. In this system, voltage sensors are connected to the R, Y, and B phases of the transformer to measure real-time voltage values. These values are continuously sent to a microcontroller such as Arduino or ESP32, where they are processed and compared with predefined safe threshold limits to identify any abnormal conditions like overvoltage, undervoltage, or phase failure.

When the system operates normally, the measured data is transmitted through the IoT module to a cloud platform, allowing users to monitor transformer conditions remotely using a mobile application. However, when a fault condition is detected, the microcontroller immediately triggers the relay to disconnect the transformer from the supply, preventing damage. At the same time, a buzzer is activated to provide a local alert, and a notification is sent to the user through the IoT application. This ensures fast fault detection, automatic protection, and real-time monitoring of the transformer system.

VII. RESULTS AND DISCUSSION

The implemented Transformer Fault Monitoring and Automation Using IoT system successfully monitors the three-phase transformer voltage in real time and detects fault conditions such as overvoltage, undervoltage, and phase failure. The microcontroller processes the sensor data accurately and responds quickly whenever abnormal conditions occur. During normal operation, the system continuously transmits voltage values to the IoT platform, allowing remote monitoring through a mobile application. When a fault is introduced, the system immediately activates the relay to disconnect the transformer and triggers a buzzer for local alert, while also sending notifications to the user through IoT.

The results show that the system provides fast response, reliable fault detection, and effective automation of protection actions. It reduces the need for manual inspection and improves the safety and efficiency of transformer operation. The discussion confirms that integrating IoT with transformer monitoring enhances real-time accessibility and ensures timely decision-making, making the system suitable for smart grid and industrial applications.

VIII. CONCLUSION

The Transformer Fault Monitoring and Automation Using IoT system effectively provides a smart and reliable solution for monitoring and protecting transformers. By continuously measuring three-phase voltage using sensors and processing the data through a microcontroller, the system is able to detect faults such as overvoltage, undervoltage, and phase failure in real time. The integration of IoT technology enables remote monitoring through a mobile application, improving accessibility and convenience for users.

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The automatic tripping of the relay during fault conditions ensures fast protection of the transformer, while alerts through buzzer and IoT notifications enhance system safety. Overall, the proposed system reduces manual intervention, increases operational efficiency, and improves reliability. It is a cost-effective and practical solution for modern power distribution systems and can be further enhanced for large-scale industrial applications.

IX. FUTURE SCOPE

The proposed system can be further improved by implementing additional advanced monitoring and protection features. Future enhancements can increase system accuracy, reliability, and automation capabilities.
Future improvements of the proposed system include:

- Integration of GSM technology for SMS alert notifications.
- Addition of voltage and current sensors for complete transformer parameter monitoring.
- Development of a mobile application for real-time monitoring.
- Implementation of Artificial Intelligence (AI) for predictive fault analysis.
- Cloud data storage for long-term performance analysis.
- Automatic transformer shutdown during severe fault conditions.
- Integration with smart grid systems for advanced power management.
- Use of advanced sensors for improved monitoring accuracy.

The future scope of the project provides opportunities for developing a fully automated smart transformer monitoring system for modern electrical power systems.

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