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DIGITAL RELAY PROTECTION OF GENERATOR TRANSFORMER USING MICROCONTROLLER

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Abstract: This paper presents a simple and efficient digital relay protection system designed for generator transformers using a microcontroller. Generator transformers play a key role in power systems and are continuously exposed to electrical faults such as overcurrent, short circuit, and earth faults. Traditional protection methods are often slow and require manual supervision. To overcome these issues, a microcontroller-based system is developed to monitor electrical parameters and detect faults quickly.

The proposed system uses sensors to measure current and voltage values, which are processed by the microcontroller. When abnormal conditions are detected, the relay is activated automatically to isolate the faulty section and protect the equipment. The system is designed to be fast, reliable, and easy to implement. Experimental results show that the system responds quickly and improves the safety of the transformer. This method can be further enhanced by integrating advanced technologies for smart monitoring.

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

I. INTRODUCTION

Power systems require reliable protection techniques to ensure the safe operation of electrical equipment such as generators and transformers. Among these, the generator transformer is one of the most important components in a power station because it transfers electrical energy from the generator to the transmission system. Any fault occurring in the generator transformer, such as overcurrent, overload, short circuit, or abnormal voltage conditions, can cause severe damage, interruption of power supply, and economic losses. Therefore, a fast and accurate protection system is essential.This project focuses on the design and implementation of a digital relay protection system for a generator transformer using a microcontroller. The system continuously monitors current and voltage parameters on both the primary and secondary sides of the transformer through suitable sensors. The sensed signals are processed by the microcontroller, which detects abnormal conditions and activates the relay circuit to isolate the faulty section from the power system.The proposed system improves protection performance by providing quick fault detection, reduced response time, and efficient system monitoring. It also offers flexibility for future modifications and integration with modern power system automation techniques. This project demonstrates the practical application of microcontroller-based digital protection in enhancing the safety and reliability of generator transformer operations.

II. LITERATURE REVIEW

Many researchers are discussed the Digital Relay Protection of Generate transformer in Thermal Power Station Using Microcontroller in different manners with different criteria. Many researchers are developed and studied the Digital Relay Protection of Generator transformer like Murty VVS. Yalla and Donald L. Homak, Shrikh Shadir Monika Sen, Jyoti Sahu, Yamini Sahu, Prot Sandeep Simkuwar etc.

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State of Art: This literature review of the generally accepted forms of relay protection for the synchronous generator and its excitation system is presented. This guide is primarily concerned, with protection against faults and abnormal operating conditions for large hydraulic, steam, and combustion-turbine generators IEEE Guide for AC Generator Protection .This literature review proposes the operation of customer-owned generation in parallel with a utility system introduces the potential for hazards and problems in both the utility and the customer system and protection schemes for intertie protection can represent a major portion of the overall installation cost. Advances in digital technology, signal processing algorithms, advanced displays and user interface designs make it possible to integrate protective functions into a single digital relay, providing an economically viable alternative for the protection of the intertie and generator. In addition, digital technology provides other advantages. Murty V.V.S. Yalla and Donald L. Hornak, "A Digital Multifunction Relay for Intertie and Generator Protection", Canadian Electrical Association, March 1992, Vancouver, British Columbia]

III. EXISTING SYSTEM

The existing system for generator transformer protection is based on conventional digital relay circuits using PIC16F90. In this system, the input voltage is first monitored using a voltage protective relay and then supplied to the transformer. An overcurrent protective relay is used to detect excessive current conditions, ensuring basic protection against overloads and faults. The system utilizes current sensors, temperature sensors, and Analog-to-Digital Converters (ADC) to convert analog signals into digital form for processing by the microcontroller.
Disadvantages: High power consumption, lower performance, wired communication, slower response,no remote monitoring

IV. PROPOSED SYSTEM

The proposed system introduces an advanced and efficient protection scheme using the MSP430, which enhances system performance and reliability. The generator transformer is continuously monitored using multiple sensors, including a current transformer (CT) for current measurement, a temperature sensor, and an oil level sensor. These parameters are crucial for detecting thermal faults, insulation failure, and oil degradation in transformers.

The microcontroller processes real-time data and performs intelligent decision-making for protection. A relay driver and relay unit are used to isolate the transformer during fault conditions. The system also includes an LCD display for local monitoring and a buzzer for fault indication.

A key improvement is the integration of an Internet of Things (IoT) module, which enables wireless communication with a cloud server. This allows remote monitoring, data visualization, and fault analysis through mobile or web applications. The power supply unit ensures stable DC output using rectification, filtering, and voltage regulation. Overall, the proposed system provides real-time monitoring, faster response, improved accuracy, and smart protection features, making it suitable for modern power systems.

Advantages:
- Remote monitoring
- High accuracy
- Low maintenance
- Automatic operation
- Cost-effective
- Fast fault detection

V. SYSTEM ARCHITECTURE

The system architecture of the Digital Relay Protection of Generator Transformer using Microcontroller consists of sensing units, processing unit, protection unit, display unit, and IoT communication module. The power supply section converts the 230V AC input into regulated DC power using a step-down transformer, rectifier, filter, and voltage regulator to provide stable power for all electronic components. The generator transformer parameters are continuously monitored using a current transformer (CT), voltage sensor, temperature sensor, and oil level sensor. These sensors send analog signals to the Arduino Uno, where the data is processed and compared with preset threshold values.

If any abnormal condition such as overcurrent, overvoltage, overheating, or low oil level is detected, the microcontroller sends a control signal to the relay driver circuit, which activates the relay to disconnect the transformer from the supply. Simultaneously, the buzzer provides an alarm indication, and the LCD display shows real-time system

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parameters and fault conditions. The system also incorporates the ESP8266 for IoT-based communication, enabling wireless transmission of data to the cloud for remote monitoring and visualization through mobile or web applications. Thus, the system architecture ensures efficient monitoring, fast fault detection, reliable protection, and smart transformer management.

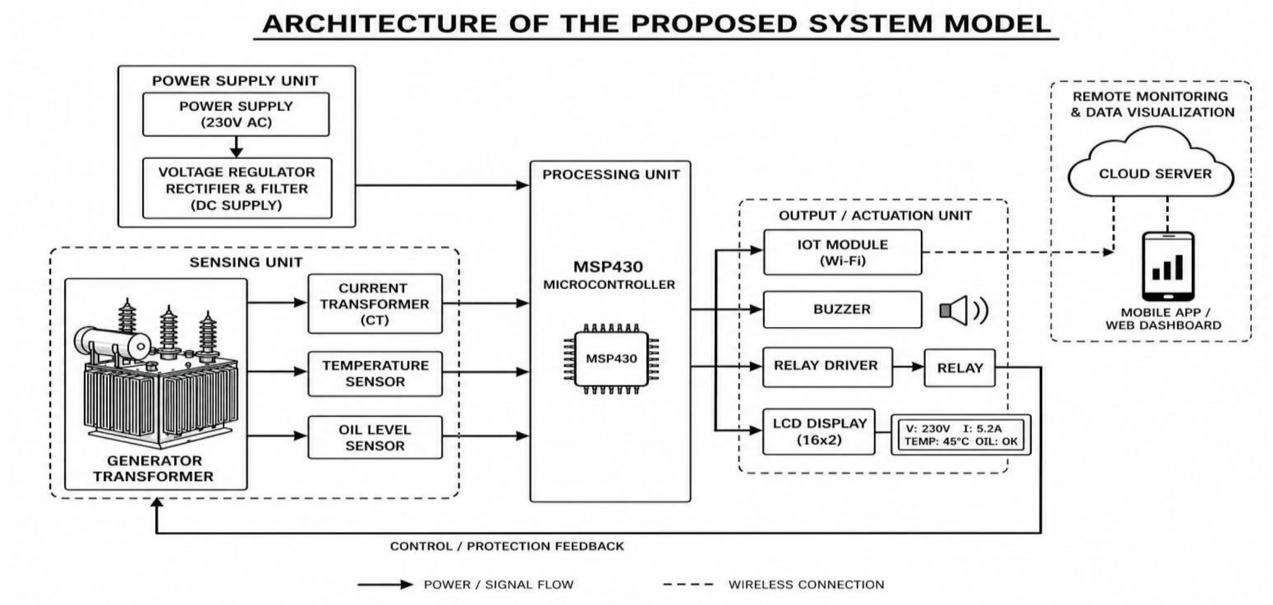

Fig. 1 System Architecture of Digital Relay Protection of Generator Transformer using Microcontroller

Data Flow Architecture

The data flow architecture describes how information moves through different components of the proposed system.
Initially, sensors continuously measure transformer parameters such as temperature, voltage and current. These values are converted into electrical signals and sent to the Node MCU microcontroller.
The Node MCU processes sensor data and compares the values with predefined threshold levels. After processing, the data is transmitted to the cloud platform through Wi-Fi communication.
The user can monitor transformer conditions remotely through the IoT dashboard. If any abnormal condition is detected, alert notifications are generated immediately.

VI. HARDWARE COMPONENTS

A. Arduino UNO:

- Acts as the main processing unit
- Performs data acquisition and fault detection
- Controls relay and output devices

B. Signal Conditioning:

- The signal conditioning circuit converts sensor signals into a safe and suitable form for the Arduino Uno.
- It filters noise and protects the microcontroller from high or unstable electrical signals.

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. Temperature Sensor

The temperature sensor is used to measure transformer temperature continuously. It helps in identifying overheating

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conditions during operation.

E. 2-Channel Relay:

- Disconnects system during fault
- Protects transformer

F. LCD Display

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

G. Buzzer

The buzzer generates alerts during abnormal operating conditions.

H. 12-0-12 Volts Transformer

- It reduces high AC voltage into low AC voltage for the circuit operation.
- It provides safe and isolated power supply to the Arduino, relay and other components.

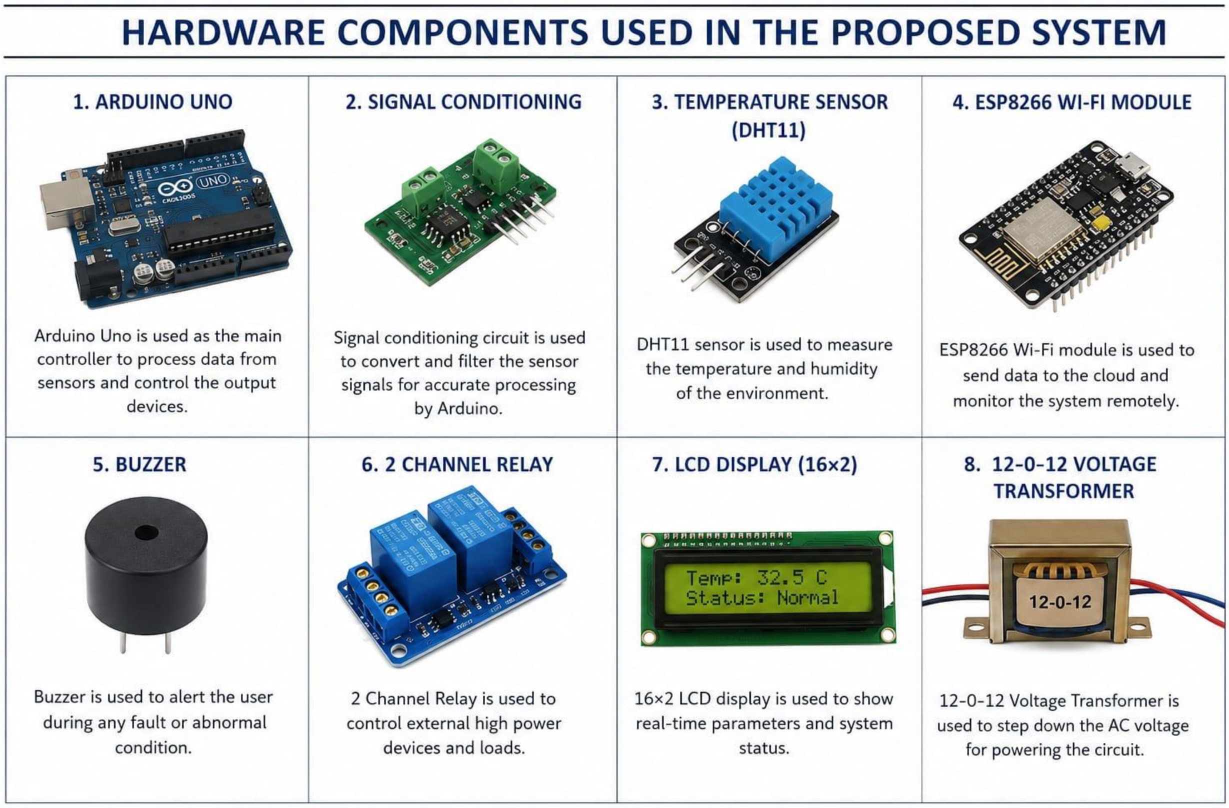

Fig. 2 Hardware Components Used in the Proposed System

VII. WORKING PRINCIPLE

The digital relay protection system works by continuously monitoring important electrical parameters of the generator transformer such as voltage, current, temperature, and oil level using suitable sensors. The sensed analog signals are conditioned and converted into digital data with the help of the Arduino Uno. The microcontroller compares the measured values with predefined safe operating limits programmed in the system.

During normal operating conditions, the relay remains energized and the transformer operates safely. Whenever abnormal conditions such as overcurrent, overvoltage, overheating, short circuit, or low oil level occur, the microcontroller detects the fault instantly and sends a control signal to the relay driver circuit. The relay driver activates the relay, which disconnects the transformer from the power supply to prevent equipment damage.

Simultaneously, a buzzer gives an alarm indication, and the fault status is displayed on the LCD screen. The system

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also includes the ESP8266 for IoT communication, which sends real-time transformer data to the cloud for remote monitoring and analysis. Thus, the system provides fast fault detection, reliable protection, continuous monitoring, and improved safety for generator transformers.

VIII. RESULTS AND DISCUSSION

The proposed Digital Relay Protection of Generator Transformer using Microcontroller was successfully designed and tested under different operating conditions. The system effectively monitored important transformer parameters such as voltage, current, temperature, and oil level using appropriate sensors interfaced with the Arduino Uno. The sensed data was continuously processed and compared with predefined threshold values programmed in the controller. During normal operating conditions, the relay remained energized and the transformer operated safely without interruption.

When abnormal conditions such as overcurrent, overvoltage, overheating, and low oil level were intentionally introduced, the system detected the faults accurately and generated a trip signal through the relay driver circuit. The relay disconnected the transformer from the supply, thereby preventing equipment damage and improving operational safety. Simultaneously, the buzzer produced an alarm indication, and the LCD display showed the corresponding fault status in real time. The integration of the ESP8266 enabled IoT-based remote monitoring, allowing transformer parameters to be viewed through cloud platforms and mobile applications.

The experimental results confirmed that the proposed system provides faster response, higher reliability, and improved fault detection compared to conventional relay protection methods. The system also reduced manual supervision and enabled continuous monitoring of transformer health conditions. Therefore, the developed protection system proves to be an efficient, cost-effective, and smart solution for modern generator transformer protection applications.
The developed system successfully identified abnormal conditions such as overheating at an early stage, thereby preventing transformer damage and improving reliability.

Analysis of Results

The proposed system provided accurate monitoring of transformer parameters and successfully detected fault conditions during operation. The Node MCU microcontroller effectively processed sensor data and transmitted it to the cloud platform through IoT communication.

The temperature monitoring section responded quickly during overheating conditions by activating the cooling fan and buzzer automatically.

The LCD display continuously showed real-time parameter values, enabling easy monitoring of transformer conditions. The system demonstrated stable and reliable operation throughout the testing process.

The results obtained confirm that the proposed system is suitable for real-time transformer parameter monitoring applications. The implementation of IoT technology improved system reliability, reduced maintenance effort, and enhanced transformer protection.

IX. CONCLUSION

In this project, a digital relay protection system for a generator transformer using the MSP430 has been successfully designed and implemented with integrated sensing of voltage, current, temperature, and oil level, ensuring reliable fault detection and protection. The system continuously monitors transformer conditions, and whenever abnormalities such as overcurrent, overvoltage, overheating, or low oil level occur, the microcontroller processes the data and generates a trip signal to the relay to isolate the transformer, thereby preventing damage and improving operational safety. The inclusion of an Internet of Things module enables real-time remote monitoring and data visualization, while the LCD and buzzer provide immediate local indication of system status. Compared to conventional systems based on the PIC16F90, the proposed system offers higher accuracy, faster response, improved reliability, and reduced maintenance, making it a cost-effective and advanced solution for modern power system protection.

X. 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 to the proposed system include:

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- 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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