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Research on Developing a Temperature Monitoring System Model for Distribution Transformers Using Iot Technology

Vu Xuan Tung[1]

[1]Department of Electrical Engineering, Thai Nguyen University of Technology

666, 3/2 street, Tich Luong ward, Thai Nguyen city, Vietnam

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Abstract

This paper presents the design and implementation of a miniature distribution transformer oil temperature indirect monitoring system using IoT technology. The system employs two DS18B20 temperature sensors to measure the oil and tank temperatures of the transformer. An Arduino Uno R3 microcontroller combined with an ESP8266 module is used to transmit the data to the Blynk Cloud platform while simultaneously displaying measurements on an LCD screen. Experiments show an average error of ±0.5 °C, a typical temperature difference of ~5 °C in steady state, a response time of 1 second, and an overheating alert triggered in <1 second. The results confirm that the system meets the requirements for real-time monitoring, is user-friendly, and is easily extendable for practical applications.

Keywords: IoT; transformer; temperature monitoring; Arduino Uno; DS18B20; ESP8266; Blynk.

1. Introduction

Transformers are essential components in power systems, responsible for transmitting and distributing electrical energy. During operation, the transformer’s oil temperature can rise, causing insulation aging and reduced equipment performance. Monitoring the transformer’s oil temperature is an important measure for early warning of potential failures.

Continuous monitoring of transformer oil temperature is a key factor in ensuring safe operation and prolonging equipment lifespan. Typically, measuring the oil temperature requires a sensor placed directly in the oil, which complicates maintenance. This research focuses on designing and prototyping a system model capable of continuously monitoring and alerting for overheating conditions of a single-phase distribution transformer during operation using IoT technology. The goal is to assist grid managers in timely fault detection and resolution. The system consists of a transformer operating temperature measurement station and continuous data synchronization to a cloud server. The temperature is measured by a non-contact method to enhance accuracy and

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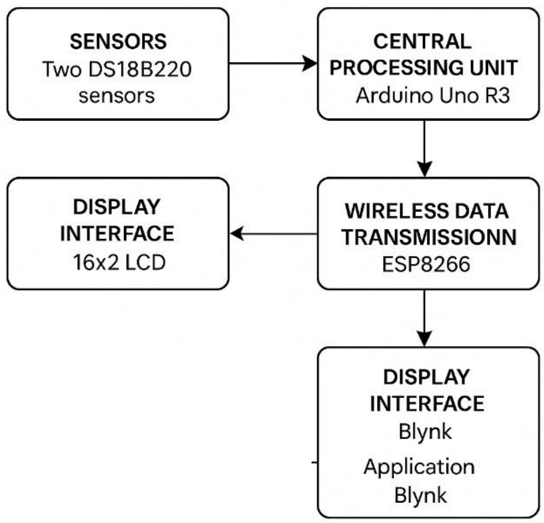
ease installation. A web-based application is developed to analyze stored data for issuing alerts. The success of this system will enable effective monitoring of operating distribution transformers, minimizing the occurrence of failures.

2. System Architecture and Design



The system consists of five main blocks: sensors, a central processing unit, a power supply, a data transmission block, and a user interface (LCD display and smartphone app).

Sensors: The system uses DS18B20 digital temperature sensors, which operate over a one-wire interface. Each sensor has a unique 64-bit address, allowing multiple sensors to be connected on a single bus. They have an accuracy of ±0.5 °C and a measurement range from -55 °C to +125 °C.

Central Processing: The core of the system is an Arduino Uno R3 microcontroller with an ATmega328P chip, providing 14 digital I/O pins and 6 analog inputs, operating at 5VDC. This controller manages all system functions.

Wireless Data Transmission: A Wi-Fi ESP8266 module provides wireless connectivity to the Blynk platform. The module can be programmed using the Arduino IDE, operates at 3.3VDC, and features UART communication and additional GPIO pins. The ESP8266 connects to a Wi-Fi network and uses the PubSubClient library to send sensor data to the Blynk Cloud at 1-second intervals.

Blynk Platform: The Arduino code was developed using the Arduino IDE. It reads temperature data from the sensors, processes it, and sends it to the ESP8266 module. The Blynk platform was used to create a user-friendly mobile interface for real-time monitoring and data visualization.

The system was designed to trigger alerts if the oil temperature exceeds predefined thresholds. Sensor data are transmitted to the cloud server and continuously updated on the user's dashboard.

Display Interface: A 16×2 LCD provides local display of measurements. The Blynk app shows graphs and alerts on smartphones and computers.

Power Supply: A 5V, 1A DC-DC converter supplies the entire system. A 12VAC output is controlled as needed.

3. Implementation:

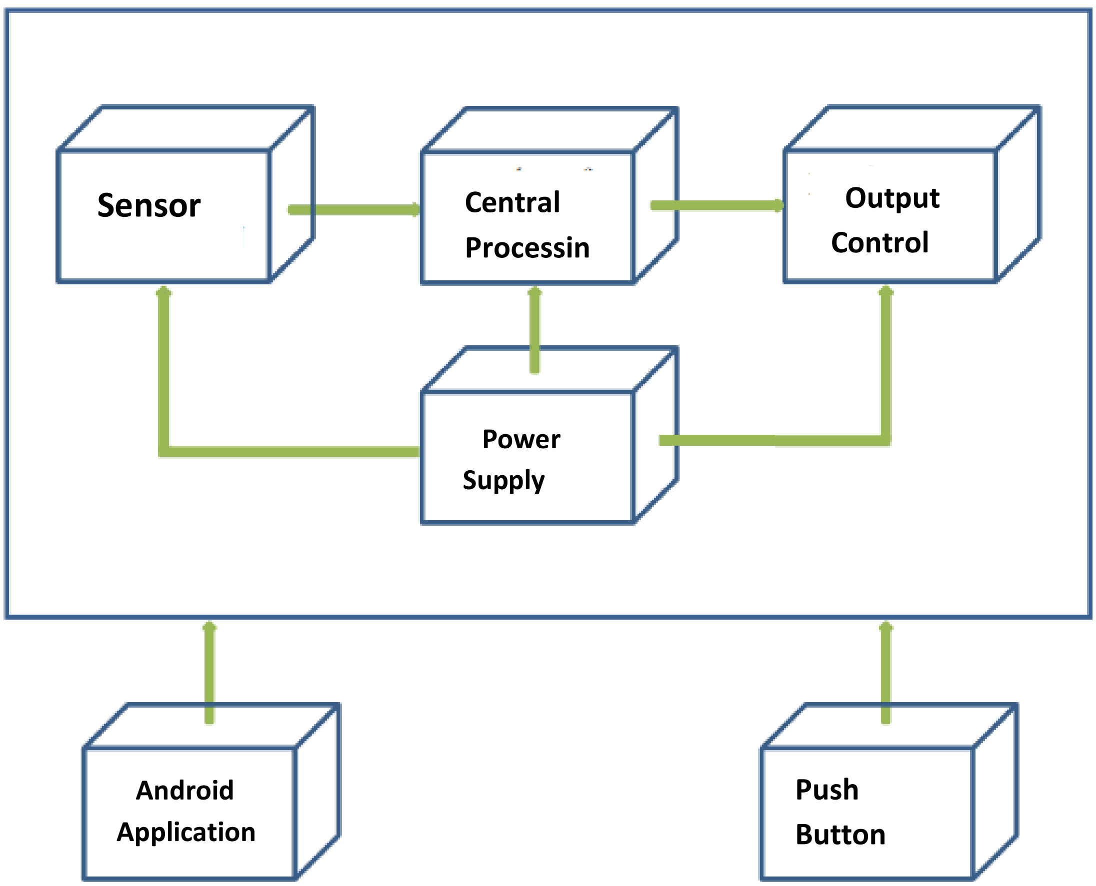


Figure 1: Block diagram of the transformer oil temperature monitoring system

The hardware components include an Arduino Uno, an ESP8266 module, DS18B20 sensors, a 16×2 LCD, and an LM2596 step-down converter. The total current draw of approximately 0.75 A is within the 1 A power module capability.

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Software: The Arduino firmware uses the OneWire, DallasTemperature, and Blynk libraries. Wi-Fi configuration is handled through a captive portal web interface (IP 192.168.4.1) using an authentication token. The Blynk Cloud stores and displays the data, with overheating alerts implemented via an LED widget and push notifications.

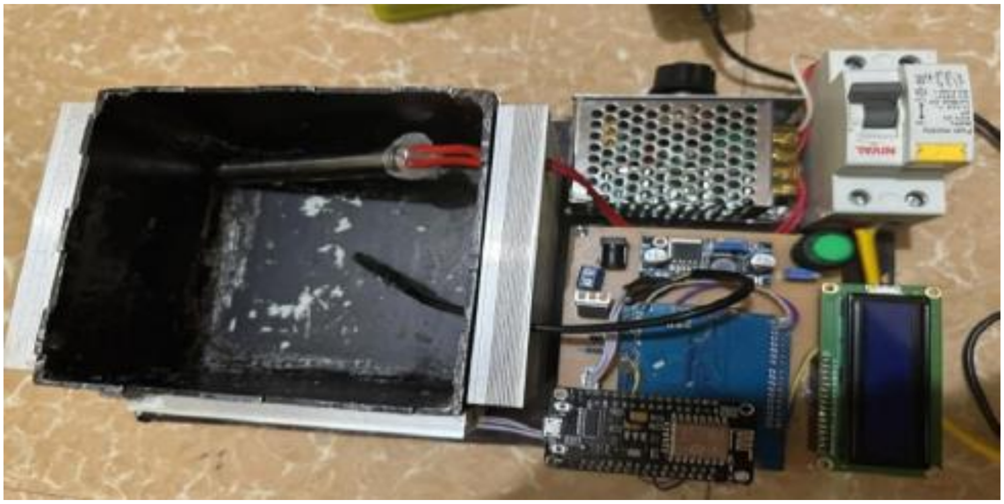
Operation:

- Power on the system: The Arduino initializes and the ESP8266 starts as an access point for Wi-Fi configuration.
- Connect to the AP and enter Wi-Fi credentials: The ESP8266 connects to the Internet.
- Sensor reading and reporting: The system reads the temperature sensors, updates the LCD, and sends data to Blynk every second.

4. Results and discussion.

4.1 Simulation model

A miniature transformer model was constructed from S400 steel, using heating elements and insulating oil to simulate real operating conditions.



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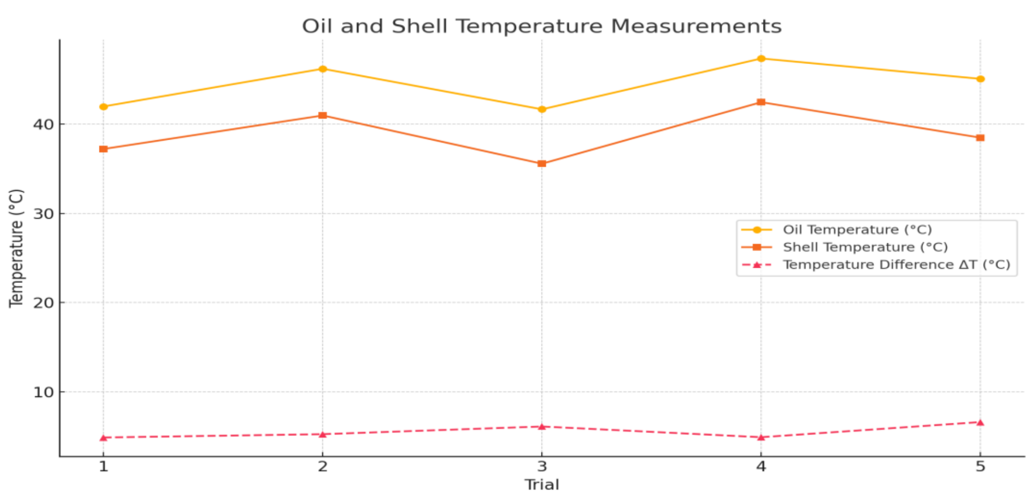
4.2 Test Results

The system was tested on a scaled-down transformer model in a laboratory setting. Temperature sensors were placed to measure both the oil temperature and the ambient temperature. Data was logged at 1-minute intervals for a period of 24 hours

Testing on the miniature transformer model at an ambient temperature of 26 °C yielded the following results:



- An average measurement error of ±0.5 °C compared to a reference thermometer; a stable temperature difference of ~5 °C.
- An average data transmission and dashboard update time of 1 second; overheating alerts (threshold <70 °C) trigger on the LCD and app in under 1 second.
- The system accurately measured and recorded temperature variations in the transformer oil. The remote monitoring system effectively displayed the data in real-time. Alerts were successfully triggered when the oil temperature exceeded the set threshold

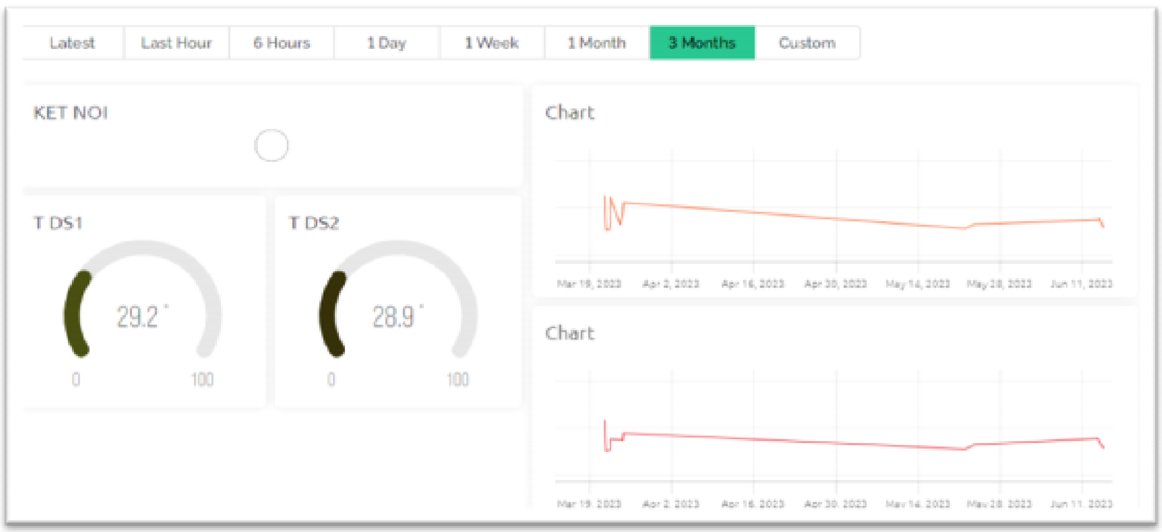


Figure 2: Illustration of Data Storage Architecture on the Cloud Server

Figure 3: User Interface of the Control Screen During Full Device Activation and Shutdown

- The results demonstrate the feasibility of using an Arduino-based system for real-time transformer oil temperature monitoring. The system offers a cost-effective alternative to traditional methods. However, the current prototype is limited to a small-scale model and requires further testing in real-world conditions. Future work will focus on improving the system's robustness, accuracy, and scalability

5. Conclusion and Future Work

The internet-based indirect transformer oil temperature monitoring system using Arduino Uno R3, ESP8266, and DS18B20 sensors has been successfully implemented with high accuracy and stability, meeting real-time monitoring requirements. The system can display data locally and allow remote monitoring and control via the Blynk application. With its low cost, stable performance, and ease of deployment, the system can be extended to monitor temperatures of electrical equipment in industrial or residential settings.

Future Developments:

- Integrating the LoRaWAN protocol for extended coverage.
- Applying machine learning to analyze temperature trends for early fault prediction.
- Expanding measurements to include humidity, leakage current, and oil pressure; and enhancing connectivity security using TLS/SSL.

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