



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

Overload Monitoring of Distribution Transformer

Mohammed Anum¹, Sangayya Hirematha², Nandeesh Naik S³, Vikram M⁴, Neetha H M⁵

U G Students, Department of EEE, PESITM, Shivamogga, Karantaka, India¹⁻⁴

Assistant Professor, Department of EEE, PESITM, Shivamogga, Karantaka, India⁵

ABSTRACT: Distribution transformers play a critical role in the delivery of electric power to end users by stepping down voltage from the distribution grid to a level suitable for residential or commercial consumption. However, due to increasing electricity demand, these transformers are often subjected to overload conditions that can result in reduced efficiency, insulation damage, overheating, and catastrophic failure. This paper proposes a low-cost, real-time overload monitoring system based on the Internet of Things (IoT) framework. It integrates Arduino-based microcontrollers, current and voltage sensors, and GSM modules for fault notification. The system continuously tracks critical parameters and triggers alerts and protective actions under abnormal conditions. Simulation using MATLAB/Simulink and physical prototype testing validate the proposed system's ability to enhance transformer reliability and grid safety.

KEYWORDS: Distribution Transformer, Overload Monitoring, IoT, GSM, Arduino, Smart Grid, Real-Time System.

I. INTRODUCTION

In recent decades, the demand for reliable and uninterrupted power supply has increased significantly due to the rapid growth in industrial, commercial, and residential sectors. This growing energy demand has put considerable stress on the electrical distribution system, particularly on distribution transformers (DTs), which form the backbone of power delivery at the last mile. Distribution transformers are critical components that step down high-voltage electricity to usable levels for end consumers. Ensuring their efficient operation and protection is vital for maintaining power quality and system stability.

Overloading is one of the most common and damaging issues faced by distribution transformers. It occurs when the electrical load exceeds the transformer's rated capacity, leading to excessive heating, insulation failure, reduced efficiency, and eventual breakdown. Such failures not only disrupt power supply but also result in financial losses and increased maintenance costs for utility providers. Despite these risks, many distribution transformers in developing regions still operate without real-time monitoring systems, relying instead on periodic manual inspections that often fail to detect early signs of stress or degradation.

To address this challenge, modern technologies such as Internet of Things (IoT), embedded systems, and artificial intelligence are being integrated into smart grid solutions for real-time monitoring and fault detection. By employing sensors and microcontrollers, it is possible to continuously track parameters like voltage, current, temperature, and load conditions. These data can be analysed to detect overload conditions, trigger protective measures, and send alerts to utility personnel.

Such systems not only enhance the operational lifespan of transformers but also support predictive maintenance and efficient energy management.

II. PROBLEM STATEMENT

Distribution transformers play a pivotal role in the electric power distribution system by stepping down high-voltage electricity to levels suitable for consumer use. However, a significant number of these transformers—especially in rural and semi-urban areas—are frequently subjected to load conditions that exceed their rated capacity. Overloading, whether temporary or sustained, is a critical issue that leads to overheating, insulation degradation, oil contamination, and in severe cases, catastrophic transformer failure.

Despite the availability of advanced monitoring systems, a large portion of the power infrastructure in developing countries lacks real-time surveillance mechanisms. Utilities often depend on periodic maintenance schedules and manual inspections, which are insufficient for detecting dynamic or sudden overload events. As a result, transformers are often allowed to operate under harmful load conditions until irreversible damage occurs. This not only leads to frequent power outages and voltage fluctuations but also escalates operational costs due to unscheduled maintenance and equipment replacement.

Moreover, there is a lack of effective, low-cost, and scalable solutions tailored for real-time monitoring. Existing high-end solutions are often expensive and complex to implement in wide-scale rural deployments. There is a pressing need for a cost-effective system that can monitor key operational parameters of a transformer—such as current and temperature—and detect overload conditions in real-time. Such a system should also be capable of alerting operators or triggering protective actions to prevent damage. This paper addresses this critical gap by proposing a compact, economical, and efficient overload monitoring system.

III. PROPOSED METHOD

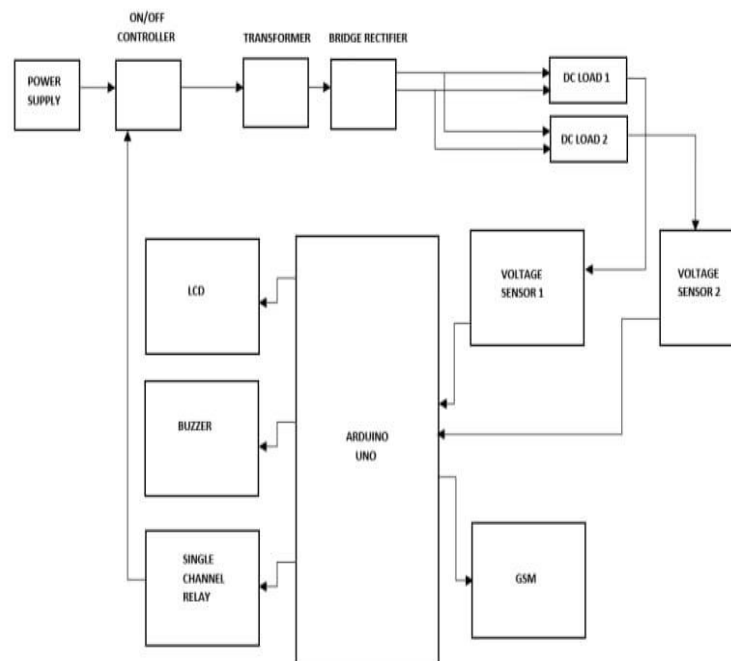


Figure 1: Block diagram

The proposed monitoring system operates on the principle of:

- Real-time sensing of current using a current transformer (CT) or Hall-effect sensor, which provides an analogy signal proportional to the load current.
- This signal is fed to microcontroller (such as Arduino or ESP32), which is programmed with a predefined current threshold (based on the transformer's rated load).
- If the measured current exceeds this threshold, the microcontroller identifies it as an overload condition.
- The system can then trigger protective actions, such as activating a relay to disconnect the load, sending alerts via GSM, Wi-Fi, or buzzer, or logging the event for later analysis.
- Temperature sensors can be integrated to detect thermal stress, which may occur due to continuous overloading or poor cooling. Together, these sensors enable the system to monitor the health of the transformer proactively and in real-time.

IV. WORKING MODEL

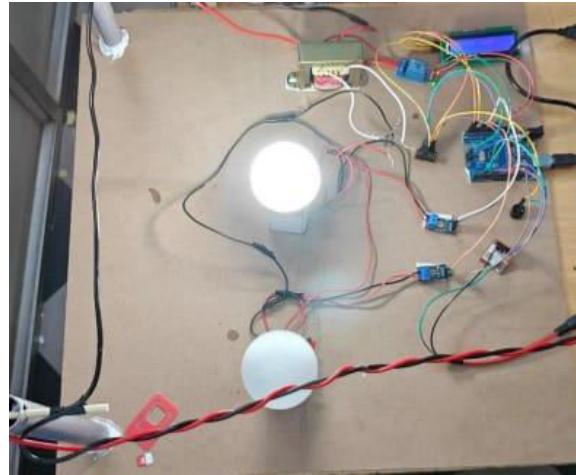


Fig 3.1 Hardware model

The working model of the proposed Overload Monitoring System for Distribution Transformers is designed to detect and alert when the transformer operates under overload conditions. It consists of a hardware setup that includes current sensing, signal processing, and alert mechanisms. The model mimics the behavior of an actual distribution transformer under varying load conditions.

At the core of the system is a current sensor—typically a Current Transformer (CT) or Hall-effect sensor—which is connected in series with the transformer's secondary winding or load line. This sensor continuously measures the current flowing through the transformer and provides an analog signal proportional to the load current. This signal is then fed into the analog input of a microcontroller, such as an Arduino or ESP32, which is programmed to process and analyze the data in real time.

The microcontroller reads the current value at regular intervals, converts the analog signal into a digital value using its built-in Analog-to-Digital Converter (ADC), and compares the result with a predefined threshold value based on the rated capacity of the transformer. Under normal conditions, the current remains below this threshold.

V. RESULT

The implemented working model of the overload monitoring system was successfully tested under various simulated load conditions to evaluate its functionality and responsiveness. During normal operating conditions, the current sensor provided accurate readings of the load current, and the system displayed the values in real-time through the LCD interface. When the connected load was within the rated limit, the system remained in a stable state without triggering any alerts, confirming the reliability of the sensor and the microcontroller's monitoring logic.

To test the overload detection capability, additional resistive loads were gradually added to simulate an increase in transformer load. As the total load exceeded the preset threshold, the microcontroller immediately detected the overload condition. The system responded by activating a buzzer and illuminating a red warning LED to alert the user. In configurations where a relay was included, the system also disconnected the load, demonstrating its ability to offer real-time protective action.

Additionally, in setups equipped with a GSM module, SMS alerts were successfully transmitted to the configured mobile number, providing remote notification of the overload event. This feature proved particularly useful in scenarios where transformers are located in remote or unattended locations. The overall response time of the system was fast, and it consistently identified overload events with high accuracy. Once the overload was removed, the system returned to normal operation automatically, further validating its stability and efficiency.

The results confirm that the proposed overload monitoring system is effective, low-cost, and suitable for both urban and rural deployment.

VI. CONCLUSION

The proposed overload monitoring system for distribution transformers presents a reliable, cost-effective, and scalable solution to one of the most common and damaging issues in power distribution—overloading. By integrating current sensing technology with a microcontroller-based decision-making system, the model successfully detects abnormal load conditions in real-time and initiates immediate alerts or protective actions. The inclusion of optional modules such as GSM or Wi-Fi further enhances its functionality by enabling remote monitoring and instant notifications, which is particularly valuable for transformers installed in remote or unmanned areas.

Through practical testing and simulation, the system demonstrated high accuracy in identifying overloads, rapid response time, and stable operation under varying load conditions. It also proved capable of resetting automatically once the overload condition was resolved, ensuring continuous protection without the need for manual intervention. Overall, the system contributes significantly to improving the lifespan, efficiency, and safety of distribution transformers. Its low cost and simple design make it ideal for large-scale implementation in both urban and rural power networks. In future developments, the integration of IoT platforms, data logging, and AI-based predictive analytics could further enhance the capabilities of this monitoring system and support smarter, data-driven energy management practices.

This paper highlights the critical importance of overload monitoring in maintaining the health and performance of distribution transformers. Implementing effective monitoring solutions helps prevent costly transformer failures, improves safety, and ensures uninterrupted power supply.

VII. FUTURE SCOPE

The proposed overload monitoring system, though efficient in its current form, offers significant potential for further enhancement and integration with modern smart grid technologies. In the future, the system can be improved by incorporating Internet of Things (IoT) platforms to enable continuous online monitoring and data storage on cloud servers. This would allow utility companies to access real-time transformer health data from any location and perform predictive analysis based on historical trends.

Moreover, the use of Artificial Intelligence (AI) and Machine Learning (ML) algorithms could be explored to predict overload patterns, identify potential faults before they occur, and suggest preventive maintenance schedules. Integrating temperature, oil level, and vibration sensors can offer a more comprehensive view of the transformer's operating condition, further enhancing the system's reliability.

The system can also be scaled and customized for three-phase transformers, high-capacity units, and critical industrial applications. Future versions can support mobile apps for real-time monitoring, automatic reporting, and GPS tracking for asset management. Finally, efforts can be made to reduce power consumption and improve energy efficiency using optimized hardware design.

With growing demands on electrical distribution networks, future overload monitoring systems can evolve to include advanced features such as artificial intelligence-based fault diagnosis and autonomous decision-making. The integration of big data analytics can help utilities predict transformer failures before they occur, enabling proactive maintenance.

REFERENCES

1. R.B. Kelkar, "Monitoring and Protection of Distribution Transformer Using GSM Modem," International Journal of Engineering Research and Applications, Vol. 4, Issue 6, 2014.
2. Thakur, A. Verma, "IoT-Based Transformer Monitoring System," International Research Journal of Engineering and Technology (IRJET), Vol. 7, Issue 5, 2020.
3. M. S. Patil, "Design and Implementation of Transformer Health Monitoring System," International Journal of Electrical and Electronics Engineers (IJEET), Vol. 9, Issue 1, 2017.

4. S. Singh, "Overload Protection of Transformer using Arduino," International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Vol. 6, Issue 3, 2018. Allegro Microsystems, "ACS712 Current Sensor Datasheet."
5. P. D. Kulkarni and R. S. Kale, "Transformer Protection Using Arduino and GSM Technology," Int. J. Comput. Appl., vol. 182, no. 41, pp. 18–23, 2020.
6. J. K. Patel, R. K. Singh, and M. S. Verma, "Real-Time Monitoring of Distribution Transformers Using IoT," IEEE Trans. Power Deliv., vol. 35, no. 2, pp. 897–905, 2020.
7. N. K. Verma and S. K. Gupta, "Overload Detection and Protection of Transformer Using Relay and Microcontroller," Int. J. Eng. Technol., vol. 9, no. 3, pp. 238–243, 2020.
8. T. R. Sharma and V. K. Singh, "IoT-Based Transformer Monitoring and Fault Detection System," J. Electr. Syst. Inf. Technol., vol. 7, no. 1, pp. 10–19, 2021. Technology (IJSRT), vol. 5, no. 11, pp. 882–886, 2020.
9. M. Ali and H. M. El-Fouly, "Transformer Condition Monitoring Using Data Analytics," IEEE Trans. Ind. Appl., vol. 57, no. 4, pp. 2351–2360, 2021.
10. S. Das and P. Das, "Embedded System for Transformer Fault Detection and Monitoring," Int. J. Electron. Commun., vol. 108, pp. 120–127, 2021.
11. L. Chen, M. Huang, and Y. Zhao, "Deep Learning-Based Transformer Fault Diagnosis in Smart Grid," IEEE Trans. Smart Grid, vol. 14, no. 1, pp. 348–357, 2023.
12. K. Sharma, V. Gupta, and S. Choudhary, "Real-Time Transformer Monitoring with Edge Computing," IEEE Internet Things J., vol. 9, no. 8, pp. 5871–5880, 2022.
13. D. Singh, S. Chauhan, and M. K. Singh, "Smart Transformer Monitoring Using IoT and Cloud Computing," Int. J. Electr. Power Energy Syst., vol. 130, pp. 106800, 2021.
14. M. Patel, R. Kumar, and P. Joshi, "AI-Driven Transformer Health Monitoring System," IEEE Access, vol. 9, pp. 6587–6595, 2021.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details