

Iot-based real time monitoring and early fault detection in power transformers

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Abstract—To reduce the unplanned breakdowns and low maintenance costs, transformers-these are essential parts in both power transmission and distribution of systems they will be monitor continuously. This can suggest real time transformer monitoring and detection of the defect which is based on IOT.A variety of characteristics, including oil level, temperature, current, voltage and load fluctuations. This data can be communicated to an IOT platform for real-time analysis and visualization. This technology primarily notifies operators via through cloud information and it can detect the conditions which are low oil levels, overheating, overloading, and the failure of insulation. Moreover, it can also permit on the operations to the safe measure in the dire circumstances. This can increase the all over effectiveness of the transformer management in the power transformer systems, facilitate maintenance, and also improves the dependability.

Keywords— *Temperature, Monitoring Sensors, load Variations, Maintenance Preventive, Fault Detection, IOT, Power Transformers.*

I. INTRODUCTION

In recent years, the demand of the electrical energy has seen a significant rise and this can move by an urban expansion, rapid industrialization, and growing incorporation of renewable energy sources which are into the contemporary power systems. The force increases demand brings the operational damage on networks of the electricity and their components. All these components, the power transformers are significant for the most efficient transmission and distribution of electrical energy by the suitable maintaining voltage levels throughout the grid [1]. The transformers are both essential and costly within power systems, their failures can result in significant power outputs, safety risks, and prolonged restoration time. The ongoing monitoring of the transformer conditions are important for the preserving system reliability and an uninterrupted power supply

transformer operating conditions is important for power supply of the transformer[2].

Traditional techniques of the transformers in the maintenance will be depends upon the inspections and offline diagnostic. While these techniques are commonly employed, they can prefer the limited sights into the real-time transformer conditions [3]. In such cases, some methods are labour-intensive, manual oversight, and may cause to the human errors during the process of monitoring. Moreover, these methods are often falls short in the fault detection at the stage of early, potentially leading to the delayed maintenance human intervention and heightened expense of the operational.

These systems monitoring continuously some parameters such as the voltage, temperature, current, oil level, load conditions, transmitting the date to the cloud platforms for real-time analysis. In recent increase the sensing technologies, embedded systems, and communication networks has been facilitated to the creation of the Internet of Things, which are based on the transformer monitoring system [4],[5]. This can always allow an early fault detection, enhances system reliability, maintenance costs will be low, and can also maintains the operational lifespan of the transformers.

A. Overview

Primarily, the power transformers play a vital role in the electrical power systems which can asset the voltage levels to up or down then this can be transmitted as well as distributed more efficiently by the electrical energy through the distribution and the transmission of the networks. The continuous growth in the electricity consumption of the transmission due to the urbanization, industrial expansion, and technical development, maintaining the development and reliability and proper transformer functioning has become the more important in the transformers. The flow of growth in the electricity consumption which is due to the industrial

expansion, urbanization and technical development in the consumption of electricity this can due to the industrial expansion, technical development, urbanization, this can also maintain the reliability of the transformer which became most important. Any damage or failure will disturb the power supply this can create safety hazards and this can lead to considerable financial losses in power transformers.

In traditional power systems, transformer maintenance has been mainly carried out through scheduled prevent maintenance and periodic inspections in offline. Although these methods help in identifying visible issues, they have certain drawbacks. Since inspections are performed only at specific intervals, they do not provide information about the transformer's in real-time operating conditions. As a result, developing faults or internal drawbacks may undergo undetected for long periods and can leads to serious failures, higher repair costs, and a reduction in the overall lifespan of the equipment in the transformers.

With the rapid increase in embedded systems, sensing devices, and communication technologies, more advanced monitoring approaches have been introduced in the system. One such approach is condition-based monitoring (CBM), this approach can focuses on continuously observing the operating condition of equipment rather than relying only on scheduled inspections in offline. By incorporating Internet of Things (IoT) technology, it is possible to monitor important transformer parameters such as , voltage, temperature, current, and oil level in real time.

B. Objectives

- To develop an IoT-based monitoring system for power transformers that continuously observes the important operating parameters in real time.
- To measure the key transformer parameters such as temperature, voltage, current, and oil level using appropriate sensors to assess the health condition of the transformer.
- To implement a microcontroller-based data acquisition system that collects and processes sensor data clearly and efficiently.
- To transmit the collected data to a remote monitoring platform using IoT communication technologies for real-time observation and analysis.
- To detect abnormal operating conditions at an early stage and generate alerts or notifications to prevent major transformer failures.
- To improve the reliability, safety, and operational efficiency of power transformers by enabling condition-based monitoring instead of traditional periodic inspections in transformers.
- To reduce the maintenance costs and downtime by providing continuous monitoring and early fault identification it is very helpful.
- To enhance power system stability by ensuring proper operation and timely maintenance of critical transformer equipment.

C. Applications

- Distribution Transformer Monitoring in Urban and Rural Network areas.
- Industrial Power Infrastructure Protection
- Renewable Energy Integration and Grid Stability
- Smart Substation Automation
- Power Theft and Overloading Detection
- Emergency Fault Response and Disaster Management

II. LITERATURE SURVEY

Shrivastava and Tripathi proposed an IoT-based transformer health monitoring system that measures important parameters such as voltage, temperature, and current using sensors. The collected data is transmitted through the internet to a remote server for continuous monitoring within system. The system enables real-time supervision of transformer conditions and helps prevent power outages by detecting faults early [6].

Hashemi and Dikmen introduced a real-time transformer conditions monitoring system integrating IoT with Dissolved Gas Analysis (DGA). Their approach evaluates the transformer's health using a Health Index (HI) model and supports advanced applications such as Digital Twin integration (DTI). This system improves fault diagnosis and enhances transformers in lifespan through continuous monitoring in the system [7].

Guardarrama, Freire, developed a wireless monitoring system for the distribution of transformers using ZigBee communication technology. The system measures electrical parameters such as voltage, current, power, energy, and frequency, and transmits the data to a remote server for analysis by continuous monitoring. The proposed architecture provides a low-cost solution with low energy consumption suitable for urban distribution networks and for monitoring [8].

Anakal, Kar, and Sangeetha proposed an IoT-based transformer monitoring and protection system using sensors and a Node MCU controller. The system monitors parameters such as voltage and temperature and sends real-time data to a control room through IoT platforms which are in available. In case of abnormal conditions, the system automatically alerts operators and protects the transformer [9].

Naveen, bharathi developed an IoT-based transformer monitoring and overload protection system that continuously tracks oil temperature, ambient temperature, voltage, and current. The system uses a microcontroller and Wi-Fi module to send data to a cloud server, enabling real-time monitoring and early detection of faults such as overvoltage, undervoltage, and overheating [10].

III. EXISTING SYSTEM

A. Introduction

Current power transformer health monitoring systems are made to keep an eye on important operating parameters and identify anomalies that could cause a transformer to fail. In the past, monitoring relied on offline testing and recurring

inspections, which offered little insight into operating conditions in real time. The power transformers are more efficient compared to the existing system of the offline testing and recurring inspections, which offered little insight of the operation system in the real-time. Although these methods help in identifying visible issues, they have certain drawbacks. Since inspections are performed only at specific intervals, they do not provide information about the transformers in real-time operating conditions.

These systems usually use sensors to track important characteristics including temperature, voltage, current, oil level, and gas generation.

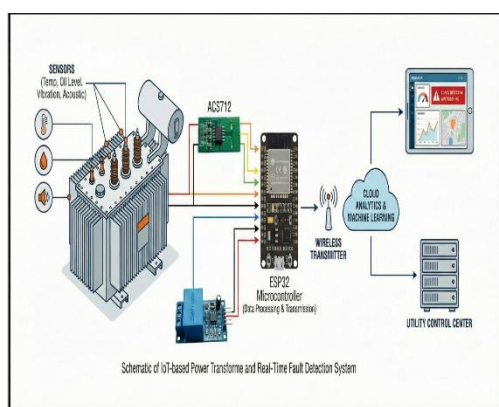


Fig. 1. Power transform and real-time fault detection

IoT-based monitoring solutions have been developed to increase transformer utility and operating efficiency thanks to developments in embedded systems and communication technologies [11]. These systems usually use sensors to track important characteristics including temperature, voltage, current, oil level, and gas generation. The gathered data will be processed by the microcontroller, which can be sent via the communication modules to the cloud systems or the remote monitoring platforms for the analysis and also it can display the characteristics of the power transformers. Preventive techniques of the maintenance are to be supported for real-time fault detection is made of possible by this design in the power transformers

The current monitoring systems will still have limited parameter coverage of the rely can be detected in threshold-based fault detection in the power systems. Furthermore, certain technologies which are not be designed for the widespread implementations [12]. To determine the systems limitations and this can create transformer better monitoring system solutions, this is important to examine their architecture and component parts in the power transformer.

B. Working Principle of Existing System

To identify any damage or abnormal scenarios will early on, the current health monitoring systems this can be regularly evaluate and analyse a critical conditions in the operation. To detect the important variables such as like voltage, current, gas concentration, and oil level, sensors are inserted on the systems in these transformers. These can provide crucial information which are regarding the transformers in operational state and general health [14].

A Microcontroller or the embedded processing unit which can receive the signal that can be obtained from the sensors after they have been transformed into the signals in the electricity. [15]. This can be serves in the system microcontroller which can be used in the primary unit.

This can detect a possible issue if any of the measured values are above the higher threshold level which can be safe in this system. This can be a sign of the problems which are including overheating, an excessive load, or degeneration of the transformer insulation. This technique will increase the power system dependability and can be avoid major increases in the power system in this the dependability and helps major failures by the identifying these issues which are early [16].

The communication technologies like the Zig-bee, GSM, Wi-Fi, and the technologies of the data is sent IOT networks to a remote monitoring platform. Operators can readily retrieve the transmitted data via monitoring dashboards since it is kept in a cloud or server-based system [17]. This can be enables to monitor the transformer condition in the real-time and respond appropriate if any of the circumstances which are found.

IV. PROPOSED SYSTEM

A. Introduction

In the generation of conventional transformer monitoring techniques, this project proposes an internet of Things (IOT) which can be based on real-time monitoring and fault detection in the power transformers. Frequently rely on the routine maintenance and manual examination that can be conventional monitoring. Moreover, to solve this problem, the suggested system keeps an eye on crucial transformer characteristics and issues early alerts when unusual operating situations arise constantly. The real-time data collection, processing, and remote monitoring are made possible this can be by the IOT communication technologies [18].

The major important parameters like the voltage, temperature, current, oil level, vibration, and gas concentration. Which are measured by the various sensors in the proposed system. The microcontroller also serves as the primary control unit, processing and analyse the gathered data to assess the performance of the overall transformer [19]. This system will detect a possible defect and can generate an alert if any of these parameters will measure by the predetermined safety limit.

The data will be stored in the cloud data server and shown on the dashboards that ca be accessible from the PCs and mobile devices. This will enhance the transformers in the power overall dependability and efficiency by the enabling operators to remotely monitors the transformer, problems, early and carry out predictive maintenance. [20].

B. Overview

The power transformers are vital parts of electrical power systems. A steady in the uninterrupted power supply which can depends on the transformer performer. This can be suggested a real-time continuous monitoring and fault detection system for the power transformers which is based on the IOT to address these issues. The main goal of this system is to be continuously monitor the transformers operational status of the unusual things. Significant characteristics such as

current, oil level, vibration, temperature, gas concentration are measured in this system are using different sensors.

This sensors are continuously gathered the data from the transformer in the real-time, which they then transmit to a microcontroller for additional processing and analysis. After analyzing the data, the microcontroller determines whether the transformer is functioning within safe bounds or not. The gathered data is sent to a cloud-based platform, where it is kept and shown via dashboards or mobile apps. This enables operators to view the transformer's operational status in real time and monitor it remotely [21].

C. Sensors Used

- a) BME280 Sensor
- b) MQ8 Sensor
- c) MPU6050 Vibration Sensor
- d) Current Sensor(Hall Effect)
- e) Voltage Sensor
- f) Sharp IR Sensor

TABLE I. SENSORS USED IN TRANSFORMER MONITOR SYSTEM

Sl. No	Sensor	Parameters Measured	Purpose
1.	BME280	Temperature, Humidity, Pressure	Detects Overheating
2.	MQ8	Hydrogen gas	Transformer Faults
3.	MPU6050	Vibration	Identifies Mechanical Transformers
4.	Current Sensor	Current	Detects Overload Conditions
5.	Voltage Sensor	Voltage	Monitors Voltage Levels
6.	Sharp IR	Oil Level	Detects Oil Leakages

D. Working Principle of Proposed System

This system can operate by using various sensors to continuously monitors a power transformer critical working monitors a power transformer characteristic. The power transformer which consists sensors include temperature, voltage, and oil level sensors, gas, vibration, temperature [22]. The sensors gather informer in the electrical properties and operating of the power transformers.

A microcontroller which can serves as the systems primary control unit, retrieves the gathered data of the microcontroller. After the process of the sensor readings, the microcontroller which can determines the transformer is functioning within safe bounds or not. The system can detect a fault if any parameter, including temperature, load current, or oil level passes, the predetermined safety of the threshold level.

After the data is processing, the microcontroller uses a wireless communication module to send the data to cloud monitoring. Operators will remotely check the transformers status from the computer or mobile device by seeing the data on the dashboard of monitoring [23]. The primary system can generate an alarm signal whenever it can be detected an

abnormal situation, excessive vibration, low oil level. Before the fault will be gets serious and says thanks to this action in the early warning. By doing these transformers this can be dependability, and guarantees of a steady of a power supply [25].

E. Block diagram

The overall structure and working of a system in a simplified form by dividing into the functional units. In a typical based sensors that collect real-time data such as temperature, light intensity, or physical changes These signals are weak or noisy, so they can pass through a conditioning unit where they are amplified and filtered. In the power systems Internet of Things based on the real-time power transformer and fault detection can be presented by this work. In the proposed system used sensors to continuously monitor critical factors such as voltage, current, vibration, and gas concentration [26].

A microcontroller processes the gathered data before sending it to the cloud platform for remote monitoring continuously. The proposed technology will give operators timely alerts and aims in the early detection of problematic conditions.

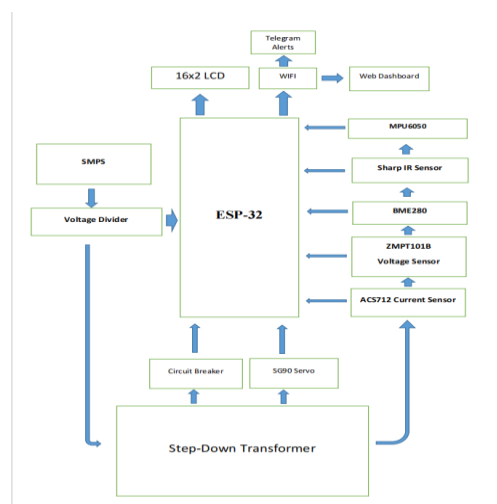


Fig.2 Block diagram of real-time fault detection

F. Applications

- Power Transmission Substations
- Distribution Transformer Monitoring
- Industrial Power Systems
- Smart Grid Infrastructure
- Remote and Unmanned Substations
- Preventive Maintenance and Asset Management
- Fault Detection and Safety Monitoring

G. Advantages

- Real-Time Monitoring
- Early Fault Detection
- Remote Monitoring Capability
- Improved Reliability of Power Systems
- Predictive Maintenance
- Cost-Effective Solution
- Scalability and Flexibility

H. Disadvantages

- Dependency on internet connectivity
- Sensor Accuracy issues
- Continuous Power requirement

V. CONCLUSION

An Internet of Things based on the real-time power transformer and fault detection can be presented by this work. In the proposed system used sensors to continuously monitor critical factors such as voltage, current, vibration, and gas concentration [26]. A microcontroller processes the gathered data before sending it to the cloud platform for remote monitoring continuously. The proposed technology will give operators timely alerts and aims in the early detection of problematic conditions.

The device can also make it possible to the continuously monitor to the transformer health and enhances the power network's overall stability and reliability of the power transformer. The monitoring process is made up of more effective and accessible from the remote areas which can be process of the power transformer by integrating sensor technology with IoT communication [27]. As the result, the proposed system solution can be regarded to a dependable and economical method for contemporary power system monitoring.

REFERENCES

- [1] D. Srivastava and M. M. Tripathi, "Transformer health monitoring system using Internet of Things", Proc. IEEE. Conc, pp. 1-5, 2018.
- [2] J. R. Guardarrama, R. C. S. Freire, and O. H. Areu, "A proposed wireless system to real time monitoring in power transformer," IEEE Latin America Transactions, pp. 1570-1575, Apr. 2016.
- [3] S. Anakal, S. R. Kar, and A. Sangeetha, "Transformer monitoring and security system using IoT", Conf. Innovative Practices in Technology and Management, pp. 1-6, 2023.
- [4] M. H. Hashemi and S. Dikmen, "Real-time condition monitoring of power transformers using the Internet of Things (IoT) and dissolved gas analysis", IEEE Scientific Technical Conf. Alternating Current Electric Drives, pp. 1-6, 2023.
- [5] S. Tenbohlen, M. Stach, and M. Koch, "Monitoring and diagnostics of power transformers", IEEE Electrical Insulation Magazine, pp. 26-35, Mar. 2016.
- [6] T. K. Saha, "Review of modern diagnostic techniques for assessing insulation condition in transformers", IEEE Transactions on Dielectrics and Electrical Insulation, pp. 903-917, Oct. 2003.
- [7] A. Abu-Siada and S. Islam, "A novel online technique to detect power transformer winding faults", IEEE Transactions on Power Delivery, pp. 849-857, Apr. 2012.
- [8] Y. Zhang, L. Wang, and W. Sun, "Smart monitoring system for power transformer using wireless sensor networks", IEEE Sensors Journal, pp. 1231-1240, Feb. 2018.
- [9] H. Gharavi and B. Hu, "Multigate communication network for smart grid", Proceedings of the IEEE, pp. 1028-1045, Jun. 2011.
- [10] L. Atzori, A. Iera, and G. Morabito, "The Internet of Things: A survey", Computer Networks, pp. 2787-2805, Oct. 2010.
- [11] IEEE Power and Energy Society, "IEEE guide for the interpretation of gases generated in oil-immersed transformers", IEEE Standard, pp. 1-45, 2019.
- [12] R. Madavan and S. Balaraman, "IoT based smart transformer monitoring system", IEEE Int. Conf. Smart Grid and Smart Cities, pp. 1-5, 2020.
- [13] A. K. S. Jardine, D. Lin, and D. Banjevic, "A review on machinery diagnostics and prognostics implementing condition-based maintenance", Mechanical Systems and Signal Processing, pp. 1483-1510, Oct. 2006.
- [14] M. Kezunovic, "Smart fault location for smart grids," IEEE Transactions on Smart Grid, pp. 11-22, Mar. 2011.
- [15] J. L. Blackburn and T. J. Domin, Protective Relaying: Principles and Applications, 3rd ed. Boca Raton, FL, USA: CRC Press, 2007.
- [16] A. S. Tanenbaum and D. J. Wetherall, Computer Networks, 5th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2011.
- [17] K. Ashton, "That 'Internet of Things' thing," RFID Journal, pp. 97-114, Jun. 2009.
- [18] R. Buyya and A. V. Dastjerdi, Internet of Things: Principles and Paradigms. Cambridge, MA, USA: Elsevier, 2016.
- [19] S. Li, L. Da Xu, and S. Zhao, "The Internet of Things: A survey," Information Systems Frontiers, pp. 243-259, Apr. 2015.
- [20] M. Chen, S. Mao, and Y. Liu, "Big data: A survey," Mobile Networks and Applications, pp. 171-209, Apr. 2014.
- [21] J. A. Momoh, Smart Grid: Fundamentals of Design and Analysis. Hoboken, NJ, USA: Wiley-IEEE Press, 2012.
- [22] F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: A survey," Computer Networks, pp. 393-422, Mar. 2002.
- [23] G. Zheng, L. Xu, and Z. Li, "An IoT-based monitoring system for power transformer," IEEE, pp. 123456-123464, 2019.
- [24] M. Muyeen, "Conditions monitoring and fault diagnosis of power transformers", IEEE, pp.1234-12360, 2021
- [25] P. T. M. Vahedi, "IoT-enabled smart monitoring of power systems: Applications in transformers", IEEE Internet of Things Journal, pp. 5678-5685, 2020.
- [26] B. Wang, "Data-driven fault diagnosis for power transformers using machine learning", IEEE Trans. Industrial Informatics, pp. 789-797, 2019.
- [27] N. Kumar and S. Zeadally, "Intelligent IoT-based monitoring in smart grid applications", IEEE Communications Magazine, pp. 90-96, 2018.