

IOT Based Transformer Health Monitoring System

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Abstract: *Communication Power transformers must work well and be reliable to keep the flow of electricity stable and uninterrupted. Standard periodic maintenance often does not find problems in their early stages, which can lead to insulation breakdown, oil breakdown, thermal stress, overloading, and unexpected outages. This paper proposes an IoT-based Transformer Health Monitoring System to address these limitations. The system can continuously and in real time monitor important operating parameters. The system uses sensors for temperature, oil level, load current, and input voltage that are connected to a microcontroller. The microcontroller processes the data and sends it to a cloud-based monitoring platform. The data analyzed by the IOT platform ensures early fault detection for maintenance planning. To support predictive maintenance, the suggested framework provides threshold-based alert notifications, historical logging, real-time data visualization, and remote access. The system creates automated alerts to stop overheating, insulation failure, and possible transformer failures when anomalous conditions are identified. This system monitors multiple transformers at different distributed substation. This IoT-enabled strategy prolongs transformer lifespan, lowers maintenance costs, minimizes downtime, and improves operational safety. The solution offers a scalable architecture for intelligent monitoring across substations and distribution networks and is in line with efforts to modernize smart grids.*

Keywords: Transformer Health, IOT-Monitoring, Sensor Integration, Microcontroller, Self-Healing Transformer

I. INTRODUCTION

Power transformers are one of the most important electrical equipment that is used in power transmission system as they perform the function of transforming the voltage levels. Hence maintenance of power transformer is mandatory; as they are located at different geographical areas periodical monitoring is not possible all the time due to insufficient man power. Due to this reason transformer failure may occur which leads to unexpected power shutdown. To overcome this shutdown due to transformer failure we proposed a system for monitoring the transformer. The aim of our project is to monitor and protect oil level, temperature and voltage and current level of transformer without involving man power. If any critical condition occurs the SMS will be sending to the control unit. This monitoring system consists of micro controller, LM35 temperature sensor, level sensor, CT PT voltage and current sensor, GSM and LCD. The proposed hardware results are obtained using miniature model of transformer. Result obtained in the proposed system with suitable modification can be applied to the real time system.

Electric power transformers are essential elements in power distribution networks, facilitating the effective transmission of electricity from power generation facilities to consumers. However, these transformers are prone to faults resulting from factors such as aging, overheating, overloading, and insulation degradation, which can lead to unplanned outages and costly repairs. Traditionally, monitoring of transformers has been done through periodic manual inspections, which are often inefficient and fail to provide real-time insights into the condition of the transformer. To overcome these limitations, recent developments in the Internet of Things (IoT) and cloud-based systems have enabled continuous



monitoring of transformer health, enhancing both reliability and performance. This paper introduces a Transformer Health Monitoring System (THMS) that leverages the IOT app, an IoT platform designed for the remote monitoring and management of connected devices. The system utilizes various sensors to monitor critical parameters such as temperature, oil level, voltage, and current, which are crucial indicators of transformer performance and can help in early failure detection. These sensors are linked to a microcontroller, like Arduino or ESP8266/ESP32, which collects data and transmits it to the IOT cloud in real time.

II. LITERATURE SURVEY

For our project we are surveying some reports and references which are helping us to make it easy and simplest and they are as follows

Several researchers have used sensing, wireless communication, and Internet of Things-based technologies to help develop automated transformer monitoring systems. Shelke (2025) highlighted the need for automation in distribution networks by proposing a real-time Transformer Health Monitoring System that uses temperature, oil level, and load sensors to get around the drawbacks of manual inspection. Erramshetti et al. (2024) created a GSM-enabled monitoring strategy that can send SMS alerts in the event of abnormal operating conditions, but their system is notification-focused and lacks immediate protective measures. IOT-driven approaches have gained attention in recent years. An IOT-based transformer monitoring architecture that uploads operational parameters to a cloud server for predictive analysis was introduced by Rajashekar et al. in 2023. In a similar vein, Zhang et al. (2020) presented IoT-based algorithms for cloud analytics-based real-time fault diagnosis. Although these systems increase prediction accuracy and accessibility, they primarily concentrate on data visualization rather than active on-site fault mitigation. GSM-based designs by Babu et al. (2022) and Mishra et al. (2021) focus on remote monitoring with microcontrollers and multi-sensor integration to detect overloading and overheating. Selvaraj et al. (2020) highlighted the role of multi-sensor fusion, which tracks oil temperature, load current, and humidity, to improve diagnostic accuracy. Diagnostic methods like acoustic emission for internal fault detection (Ma et al., 2022) and dissolved gas analysis for insulation deterioration (Bustamante et al., 2019) offer high accuracy. However, they are costly and not ideal for low-cost distribution transformers.

1. Prof. M.S. Sujatha and Dr. M Vijay Kumar proposes an GSM technique can be successfully apply to the earlier developed communication based special protection systems to increase its reliability during network interruptions. The GSM enhances speed of communication with distance independency. A suitable authenticated hardware is designed to meet the credibility of the networking. An Embedded based hardware is designed to acquire data from electrical sensing system, it sends from one network to other and change in parameters of transmission to be sensed to protect the entire transmission and distribution. GSM enables bi-directional communication as a message or data. Visual Basic software is used as interpreter among various tools and systems.

2. Bhakare Govind A, Dabe Nilesh P and Pawar S.D. Proposed a mobile embedded system to monitor and record key operation indicators of a distribution transformer like load currents, transformer oil and ambient temperatures. The proposed on-line monitoring system integrates a Global Service Mobile (GSM) Modem, with standalone single chip microcontroller and sensor packages. It is installed at the distribution transformer site an the above mention parameters are recorded using the built-in 8- channel analog to digital converter (ADC) of the embedded system. The acquired parameters are processed and recorded in the system memory. If there is any abnormality or an emergency situation the system sends SMS (ShortMessage Service) messages to designated mobile telephones containing information about the abnormality according to some predefined instructions and policies that are stored on the embedded system EEPROM. Also, it sends SMS to a central database via the GSM modem for further processing. This mobile system will help the utilities to optimally utilize transformers and identify problems before any catastrophic failure.

3. Vadirajacharya. K, Ashish Kharche, Harish Kulakarni, Vivek Landage ., proposes an past maintenance of transformers was based on a pre-determined schedule. With the advancement of communication technology now it is possible to receive fault information of transformer through GSM technology remotely to the operator and authorities so one can able to take possible solution before converting fault in to fatal situation. Depending upon fault analysis a prototype



model of micro-controller based transformer health monitoring kit is developed in laboratory. Using digital controller analysis results are regularly updated. During abnormal conditions exceeding specified limits information is immediately communicated through GSM technology to the operator and also to concerned authority for possible remedial action.

4. Anirudh Kumari, Ashish Raj, Abhishek Kumar, Sikandar Prasad and Balwant Kumar., proposes an advanced remote monitoring system for distribution transformers utilizing the existing GSM communication network, which has low investment and operation costs. It is also easy to install and use. For this purpose, we have introduced a novel software (DTMAS) and used it for three different types of distribution transformers in order to analyze voltage unbalance condition.

III. METHODOLOGY

The system It consists of transformer, oil sensor, voltage sensor, current sensor, temperature sensor, PIC microcontroller, power supply, LCD display, GSM modem, MAX 232 and relay. Normally in transformer, failure occurs due to voltage and current fluctuation, overheating, change in oil level etc. In this project, to sense this fault we have used current and power transformer, temperature sensor, oil sensor respectively.

All these sensors are connected to the transformer and its output is given to microcontroller. PIC microcontroller port is connected to address lines, GSM model and LCD respectively. When fault occurs due to above any reason then change in ratings will be shown on LCD and quick SMS will go to control room via GSM modem. A brief discussion about components used is as given below Sensors play a vital role in effective implementation of the project. As we are interested in monitoring over current, over voltage, over temperature and oil levels following sensors are selected and suitable designed with respect to prevailing conditions of power system and rating of transformer to be protected.

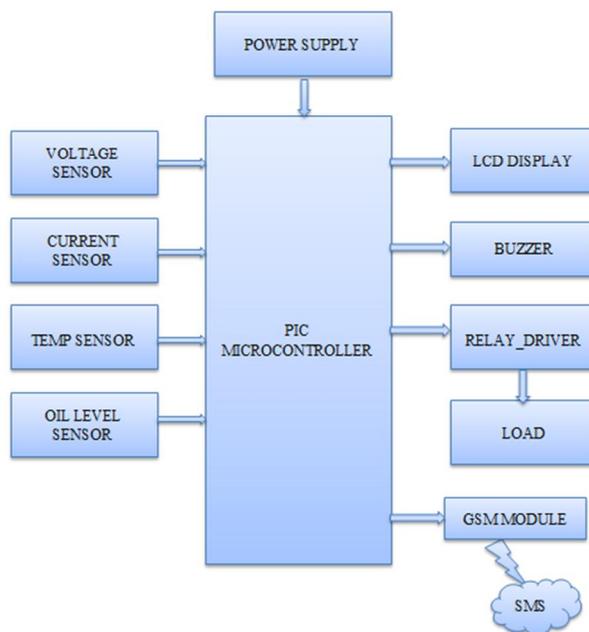


Fig. 2. Block Diagram

A. PIC 18F4520:

The PIC18F4520 is an 8-bit, 40/44-pin microcontroller featuring 32KB Flash, 1.5KB SRAM, 256B EEPROM, and nanoWatt technology for low-power operation. It supports 10-bit ADC (13 channels), multiple CCP/ECCP modules, SPI, I2C, and EUSART, operating up to 40MHz within a 2.0V-5.5V range. It is ideal for high-performance, power-sensitive embedded design.



Key Specifications

- Core: 8-bit PIC18
- Package Options: 40-pin PDIP (most common), 44-pin QFN, 44-pin TQFP
- Memory: 32 KB Flash (Program), 1.5 KB SRAM, 256 bytes EEPROM
- Operating Voltage: 2.0V - 5.5V
- Maximum Clock Speed: 40 MHz
- ADC: 13-channel, 10-bit
- Communication Interfaces: EUSART, SPI, I2C
- Timers: 1 x 8-bit, 3 x 16-bit
- Peripherals: Enhanced Capture/Compare/PWM (ECCP) module, 2 Comparators
- Power Management: nanoWatt Technology, Sleep mode

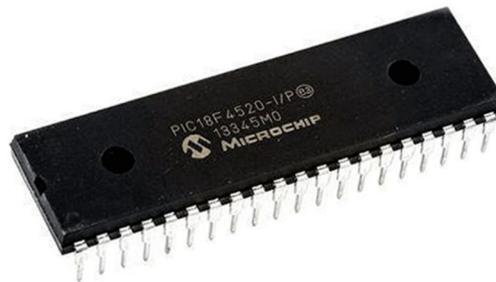


Fig. 3. PIC Microcontroller

B. VOLTAGE SENSOR:

This is a simple but very useful module which uses a potential divider to reduce an input voltage by a factor of 5. The Voltage Detection Sensor Module 25V allows you to use the analog input of a microcontroller to monitor voltages much higher than it capable of sensing.

For example with a 0-5V analog input range, you are able to measure a voltage up to 25V. This voltage sensor module also includes convenient screw terminals for easy and secure connection of a wire.

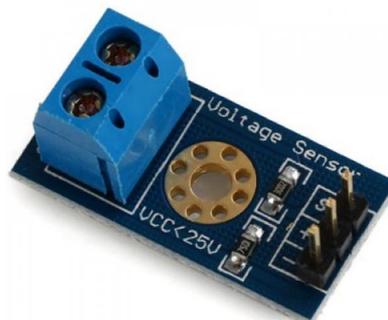


Fig. 4. Voltage Sensor

C. Current Sensor:

The 20A Range Current Sensor Module ACS712 consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field in which the Hall IC converts into a proportional voltage.

1. The low-noise analog signal path



2. Device bandwidth is set via the new FILTER pin
3. 5 μ s output rise time in response to step input current
4. Small footprint, low-profile SOIC8 package
5. 2.1 kV RMS minimum isolation voltage from pins 1-4 to pins 5-8
6. 5.0 V, single-supply operation
7. 66 to 185 mV/A output sensitivity
8. Output voltage proportional to AC or DC currents



Fig. 5. Current Sensor

D. Float Sensor/ Level sensor:

A float switch is a type of level sensor, a device used to detect the level of liquid within a tank. It is a simple structure, easy to use level control device; moreover, it is neither a complicated circuit nor does it provide power. This switch has a mechanical switch than the average small sized switches.

As long as the material used is in the correct shape and nature of any liquid or pressure, you can control the temperature.



Fig.6. Float Sensor

E. GSM Module:



Fig.7. GSM Module



SIM900A RS232 for PC or TTL microcontroller interface with DTMF active feature. The GSM/GPRS Cellular Module for Microcontrollers/ Embedded Systems/ Home automation is complete in all respect ready to plug-in interface for your microcontroller(Arduino,Raspberry pi, Atmega, PIC, Basic Stamp, 8051, AVR etc) with an SIM900A GSM/GPRS cellular module. This allows you to easily add SMS, GSM/GPRS, and TCP/IP functionalities to your microcontroller based project. Dual Mode functionality - connect with RS232 serial port for direct PC interface or through TTL I/O interface for microcontroller based autonomous projects.

IV. RESULT

The developed IoT-based Transformer Health Monitoring System successfully monitored key transformer parameters in real time and displayed them locally as well as transmitted them for remote supervision.

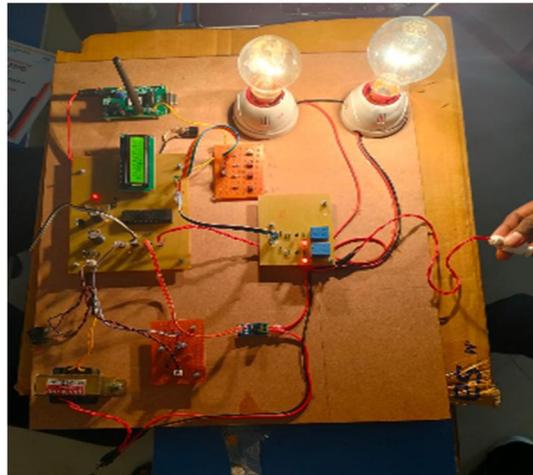


Fig.8. Photograph of Hardware

V. CONCLUSION

The following work elaborates on a lightweight, IoT-driven Transformer Health Monitoring System to effect unobtrusive surveillance over key transformer health signals-AC voltage, AC current, body temperature, and oil level. These parameters are important determinants for ascertaining how well the transformer is working and how well and reliably it is likely to perform. By combining easily available sensors with an Arduino-based controller and IoT communication modules, the setup collects precise data and sends it over to cloud platforms in real time to enable remote oversight without resorting to onsite checks. Tests have shown that the system will reliably flag abnormal conditions such as over- and under-voltage, overloading, excessive temperatures, and low oil levels. Threshold alerts trigger quick notifications and protective actions that support preventive maintenance before failures become major. IoT dashboards provide intuitive views of live data, past trends, and event histories to bolster condition-based and predictive maintenance approaches. In other words, the presented method demonstrates that an inexpensive, scalable, and energy-efficient transformer monitoring system can be realized using commercially available sensors and microcontroller hardware. This design aims at enhancing operational safety while reducing hands-on visual inspections, unexpected outages, and increasing reliability in distribution networks. This represents a very good option for modern distribution systems and smart grids.

VI. FUTURE SCOPE

There is a lot of room for future development and widespread implementation of the suggested Transformer Health Monitoring System. The combination of machine learning and artificial intelligence methods is one significant area for development. Advanced predictive maintenance is made possible by the development of predictive models that forecast faults like insulation degradation, oil aging, and abnormal thermal behaviour through the analysis of historical sensor



data. By adding more sensing units like dissolved gas analysis sensors, partial discharge sensors, vibration sensors, and humidity sensors, the system can also be expanded to support three-phase transformers and substation-level monitoring. A more thorough evaluation of transformer condition and early fault detection capabilities would be possible with these additions. Future work might involve creating a specialized mobile application with an intuitive user interface that offers real-time visualization, alerts, health indices, and maintenance suggestions. By enabling local data processing, lowering communication latency, and boosting dependability during network outages, the use of edge computing platforms like the Raspberry Pi or ESP32 can further improve system performance. Additionally, to guarantee data integrity, transparency, and tamper-proof storage of transformer health records, secure data management strategies like block chain can be investigated. By incorporating solar-powered modules, the system can be made energy independent for deployment in remote and rural areas. Additionally, centralized monitoring and coordinated control of numerous transformers across large geographic regions would be made possible by integration with current SCADA and smart grid infrastructures. The suggested system can be developed into a robust, scalable, and industry-ready transformer health monitoring solution with the use of industrial-grade hardware, weatherproof enclosures, and long-range communication technologies like LoRa WAN.

ACKNOWLEDGMENT

It gives us great pleasure in presenting the paper on "IOT based transformer health monitoring System". We would like to take this opportunity to thank our guide, Prof. Shinde M.J., Professor, Electrical Engineering Department, Samarth Polytechnic, Belhe for giving us all the help and guidance we needed. We are grateful to her for her kind support, and valuable suggestions were very helpful.

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