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IOT-BASED TRANSFORMER HEALTH MONITORING SYSTEM

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Abstract: *A transformer is the most important and basic equipment of a power system. It is the heart and soul of the power system. This project aims to give a perfect solution to transformer monitoring as each of us are dependent on the smooth conductance of the transformer.*

In this project, we will be monitoring different transformer parameters like Current, Voltage, Temperature and Oil level of this static machine. Then that all data will be supported by a GSM-based system so that if violations of parameters happen then it sends respective information to the phone numbers linked to the system. This gives a dynamic solution to most of common faults which generally take place in rural parts that can be eliminated by this. This system is controlled by an IOT (Internet Of Things) based setup Controlled and co-ordinated by Arduino. Which provides a cheapest solution to present problems.

Keywords: *Transformer, GSM, Internet Of Things, Arduino.*

1. INTRODUCTION

Transformers are a very crucial component of any power system and thus of grid infrastructure. Their efficient operation is essential for ensuring the reliability of the system. During working under tremendous load, transformers are prone to failure due to various reasons such as overloading, overheating, insulation failure, etc. these things can cause blackouts, safety hazards, and economical losses also.

In contemporary times, the reliance on electricity has become ubiquitous to the extent that it is challenging to sustain daily life without access to it, even for a brief period. The provision of power supply is an essential prerequisite for the operation of any activity, be it residential, industrial or manufacturing. There are a number of implicit and explicit causes for the transformer's deteriorating performance.

To address the aforementioned challenges, a transformative monitoring system based on the Internet of Things (IoT) can be designed and implemented. This system leverages a diverse array of sensors to capture and record real-time data pertaining to crucial performance indicators of the transformer. Specifically, the system monitors key parameters including temperature, current, voltage, and oil level. By employing IoT technology, this monitoring system facilitates continuous and comprehensive monitoring of the transformer's operational characteristics, enabling timely detection of any abnormalities or deviations from optimal performance.

In a recent scenario such performance parameter check is done by physical means but this system aims to reduce human efforts in the power system and allows it to be self-sufficient. This project will help us to find and encounter different problems before any false condition, thus resulting in a long life for the transformer.

2. LITERATURE REVIEW

In a study conducted by Mao [1], a wireless monitoring system utilizing the General Packet Radio Service (GPRS) was proposed for power distribution transformer stations. The system comprised various modules, including a sensor module, data transmission module, data receiving module, and data analysis module. The sensor module was responsible for gathering important operational parameters of the transformer, such as temperature, current, and voltage. Subsequently, the collected data was transmitted to the data transmission module via GPRS. The data receiving module then received and stored the transmitted data in a database, facilitating further analysis and evaluation. The system was tested in a power distribution transformer station, and the results showed that it could effectively monitor the transformer's operating parameters.

Zigbee technology was proposed for use in a wireless system for monitoring and protecting transformers by Ravishankar et al. [2]. There are four separate modules that make up the system: sensors, Zigbee, control, and security. The module responsible for gathering the operational parameters of the transformer is the sensor module, which transmits the data wirelessly to the Zigbee module. The control module utilizes the gathered data to regulate the transformer's functions, whereas the protection module is accountable for identifying and safeguarding the transformer against diverse fault categories.

Buyung Sofiarto et.al. [3] tested signal processing methods to extract power transformer characteristic parameters from vibration signal monitoring. The authors analyzed the signal using different transformations, including wavelet, Hilbert-Huang, and empirical mode decomposition. The results showed that the wavelet transform technique was the most suitable for extracting the characteristic parameters.

Drasko Furundzic et al. [4] proposed a fault detection system for power transformers based on a neural network ensemble. The authors developed a fault detection algorithm based on the wavelet transform, and the ensemble of neural networks was used to improve the detection accuracy. The proposed system was tested on a real transformer, and the results showed that it could detect faults with high accuracy.

3. GSM TECHNOLOGY

In 1991 it was discovered and after that, it became so much popular that it is still the best to communications. In world over 80% of the global market is of this GSM technology. It uses a strong combination of time division multiple access and frequency division multiple access that allows multiple users to share and use the same frequency band. it offers a variety of voice calls, text messaging (SMS), multimedia messaging, and data transfer services. GSM typically operates in 900MHz OR 1800 MHz frequency band with respect to devices and reasons of operations.

4. SYSTEM DESIGN AND ARCHITECTURE

This transformer monitoring system consists of the remote terminal unit which is the brain of this system which is Arduino UNO R3 which is supported by Atmega 328p microcontroller, the GSM-based transmission network. this remote terminal unit consists of Arduino and various peripheral devices like LCD display, gsm module, and respective sensors required for the data collection and monitoring.

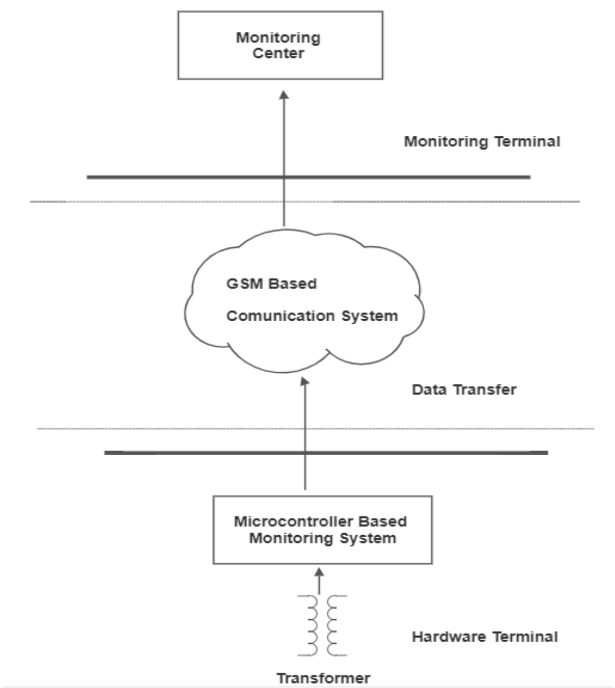

Fig.1.Architecture of transformer monitoring system

5. METHODOLOGY

We have worked on this project in two different modes 1. Software mode in order to study actual requirements and parameter checks for a project and 2. In software mode where we worked on the basis of software results.

1. Software Model

We used Proteus 8 software to design a software simulation of this project. Where we used all the sensors and their related libraries for the smooth conductance of this simulation. here also we used the GSM module for communication purposes and after all connections we completed one of the most important task which is the coding of the project. Here is the image of that software model.

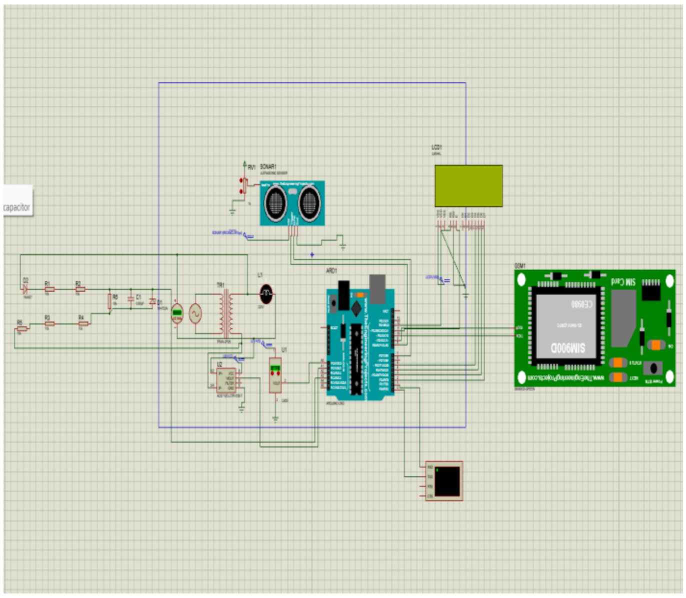

Fig.2. Simulation result of Proteus 8

2. Hardware Model

This hardware modeling is performed in two parts one is a remote terminal unit and another is a hardware terminal unit.

A. Remote Terminal Unit:

Arduino UNO R3 is the key and like the heart of this IoT system as a microcontroller fitted inside it which is Atmega 328p. it is further connected to different sensors which are responsible for data collection. GSM SIM 900A is also connected to this Arduino in order to send information about collected data to the user end or monitoring end. in short GSM module is the soul of this system as it facilitates communication from one end to the other end.

B. Hardware Terminal Unit:

In this section, all the working sensors and other peripherals for RTU are there. It consists of a current sensor, temperature sensor, oil level sensor, LCD display and GSM module. when any fluctuation in standard value happens all the information will be shown on LCD display and SMS will be delivered to the registered number.

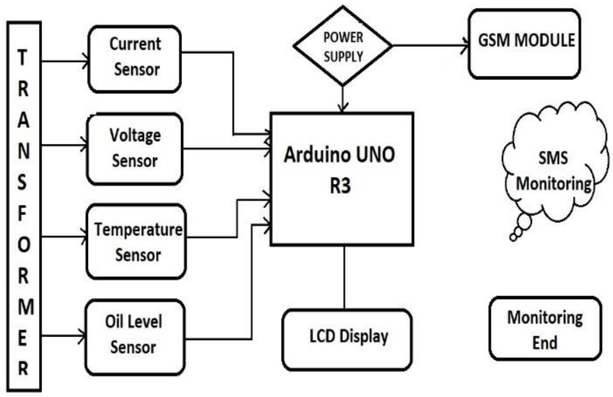

Fig.3. Block diagram of monitoring system for transformer

a) Temperature Sensor:

BMP 180 temperature sensor is digital sensor that can measure temperature with high accuracy. This sensor uses micro electro mechanical system sensor technology to detect temperature. it can operate over a wide range of - 40°C to 85°C and is commonly used in various applications.

b) Current Sensor:

The ACS 712 is a sensor that utilizes the hall effect to measure both alternating and direct currents with a high degree of accuracy and precision. The device utilizes a linear analog output voltage which exhibits a direct correlation with the current being measured. The ACS 712 sensor utilized in our project possesses a current rating of 20A and is available in various other current ratings.

c) Oil Level Sensor:

In this project, we are using the ultrasonic sensor for oil level monitoring. this sensor totally works on sound waves. It emits high-frequency sound waves and calculates the time taken to for the waves to bounce back after hitting the surface of the oil. Thereby using this technique, we measure the distance and the oil level is monitored.

d) Voltage Sensor:

ZMPT101b measures 0-250 V AC voltages. Microcontroller projects use it. A fixed and variable resistor voltage divider circuit steps the measurement level. The voltage signal is amplified by an internal amplifier from the voltage divider's output so that it can be read by the microcontroller.

e) Arduino UNO R3:

Arduino UNO R3 is a popular microcontroller-based board. Which is mainly connections of different pins like digital and analog to the ATmega328P microcontroller chip. It has the following basic features-

The operating voltage of the system is specified as 5V. It is recommended to provide an input voltage ranging from 7V to 12V. The system offers a total of 14 digital I/O pins, out of which 6 are capable of providing PWM (Pulse Width Modulation) output. Additionally, there are 6 analog input pins available for use. The maximum DC current that can be drawn from each I/O pin is 20 mA, while the 3.3V pin can handle a maximum DC current of 50 mA. The system is equipped with 32 KB of flash memory (ATmega328P) for program storage, 2 KB of SRAM (ATmega328P) for temporary data storage, and 1 KB of EEPROM (ATmega328P) for non-volatile data storage. Lastly, the clock speed of the system is set at 16 MHzf) GSM 900A Module:

This modem operates on a 900 MHz frequency band. It is used in this project for communication purposes. It provides voice, SMS, and data communication capabilities over cellular networks. It is based on the SIM900A chipset. It has the following features :

1. Quad-band operation: GSM 850/900/1800/1900 MHz

2. GPRS (General Packet Radio Service) multi-slot class 10/8

3. Support for voice and SMS communication

4. Support for TCP/UDP protocols for data communication

5. Built-in Bluetooth and FM radio capabilities (depending on the module variant)

6. Low power consumption: standby current of less than 1 mA

7. Compact form factor: typically in the form of a small PCB

g) LCD Display:

We have used a 16x2 LCD display to monitor all the information. It simply contains 16 columns and 2 rows of characters which allows 32 displayable characters at a time. It has the following basic features:

Character size: 5x8 dots

Display size: 84mm x 44mm x 11mm

Supply voltage: 5V

Number of characters: 16 columns x 2 rows (32 characters)

Interface: Parallel or Serial

Backlight: may be included as an optional feature

Viewing angle: typically around 6 o'clock

Threshold-based algorithm /Code:

Step 1: For Current, voltage, temperature and ultrasonic sensor using the Threshold based algorithm:

1. Setup sensors and GSM/GPRS module.
2. Loop:
   3. Read temperature sensor data.
   4. If current temperature exceeds maximum threshold:
      a. Generate an alert for transformer overheating.
      b. Send an SMS message to the defined phone number.
   5. Read current sensor data.
   6. If current exceeds maximum threshold:
      a. Generate an alert for potential transformer damage due to excessive current.
      b. Send an SMS message to the defined phone number.

7. Read voltage sensor data.
8. If voltage exceeds maximum threshold:
   a. Generate an alert for potential transformer damage due to excessive voltage.
   b. Send an SMS message to the defined phone number.
9. Read ultrasonic sensor data.
10. If distance is below minimum threshold:
   a. Generate an alert for potential transformer damage due to insufficient lubrication.
   b. Send an SMS message to the defined phone number.
11. Else if distance is above maximum threshold:
   a. Generate an alert for potential transformer damage due to overfilling.
   b. Send an SMS message to the defined phone number.
12. Wait for the next data reading.
13. End loop.

Step 2: Infinite Loop (Detail inside the loop)

read temperature sensor data

if current temperature exceeds the maximum threshold then

generate an alert indicating that the transformer is at risk of overheating

send an SMS message to the defined phone number

endif

read current sensor data

if current exceeds the maximum threshold then

generate an alert indicating that the transformer may be at risk of damage due to excessive current

send an SMS message to the defined phone number

endif

read voltage sensor data

if voltage exceeds the maximum threshold then

generate an alert indicating that the transformer may be at risk of damage due to excessive voltage

send an SMS message to the defined phone number

endif

read ultrasonic sensor data

if distance is below the minimum threshold then

generate an alert indicating that the transformer may be at risk of damage due to insufficient lubrication

send an SMS message to the defined phone number

else if distance is above the maximum threshold then

generate an alert indicating that the transformer may be at risk of damage due to overfilling

send an SMS message to the defined phone number

endif

wait for the next data reading

6. RESULTS

Upon conducting tests on the implemented system, the obtained results are as follows:

1. If the current exceeds 17A, it will be identified as a current fault.
2. If the temperature exceeds 75 degrees Celsius, it will be recognized as a temperature fault.
3. If the oil level drops below 100 cm, it will be classified as an oil level fault.

To facilitate the detection of these abnormalities, the RTU (Remote Terminal Unit) LCD display will undergo changes to reflect the respective fault conditions. Furthermore, the GSM module integrated into the system will transmit the collected data to the monitoring endpoint for further analysis and assessment.

7. CONCLUSION

In this project, we have developed and implemented GSM based transformer monitoring system which is supported by the Internet of Things. It is a very nice solution to manual monitoring of the transformer where we are monitoring current, oil level, temperature, and voltage at a time. which is controlled by a microcontroller-based assembly. As it acts as a data acquisition and transmission system. At the monitoring node, we can take action if any abnormality happens in the system. Thereby preventing catastrophic failure of the system.

7.FUTURE WORK

In the future, we can make a data acquisition system so strong that we can analyze the history of the transformer thereby we can predict the loading conditions which will allow us to forecast things like if any kind of failure is there or not. To make it more advanced we can accumulate data on all transformers on the same feeder and it can be utilized for future monitoring and protection purpose.

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