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Original Article

Transformer Health Monitoring System using GSM Technology

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Abstract *- Automation plays a significant role in sensing faults and protecting distribution transformers. Automation also provides excellent reliability, reduces human effort, and provides a better protection system used to improve the quality of electrical service. The distribution transformer is one of the most expensive components, and protection against faults and failures is critical. This project is about designing and implementing a GSM-based distribution transformer monitoring and fault detection system. Different types of sensors are installed at the transformer site, and parameters like load current, oil level and ambient temperature are recorded and monitored. The current Sensor is used to measure the load current, and the oil level sensor is used to measure the oil level, thereby indirectly measuring the ambient temperature. This proposed system will trip the load, and the engineer will indicate if any abnormal condition or parameters are not directly limited by the GSM module, showing the abnormality. Also, if an overload or overheating in the distribution transformer occurs, the Relay will trip the load, and an SMS message will be sent to the engineer indicating the type of fault.*

Keywords *- Distribution transformer, Protection, GSM, Current sensor, Oil level sensor.*

1. Introduction

The literature related to the research topic has been reviewed for the last twenty years to find out work carried out by diverse researchers. So many systems for control are designed and remote monitoring as experimental research platforms or commercial products. They say that most of the research was carried out in the following categories:

- Transformer failures, causes & impact.
- Design and implementation of real-time transformer and monitoring system using GSM.
- Development of I.O.T. and controlling of distribution transformers.
- Achievement of transformer protection by the intelligent electronic device.
- Applications of infrared camera for monitoring of transformer bushing.

2. Literature Survey

The research proposal termed "Development of a Novel Fault Management in Distribution System Using Distribution Automation System in Conjunction with GSM Communication Development and Implementation of Novel Fault Management at Low Voltage to Improve Power Reliability for Consumers" focused on the development and implementation of novel fault management at low voltage to improve power reliability for consumers. Their system includes a current sensor as a field data interface device, a microcontroller as a remote terminal unit, a GSM communication network, a computer as a master terminal unit, and essential visual software as a human-machine interface (HMI). After a problem occurs, a fault design development of the WCDMA-based DTMS 12 management technique has been devised to successfully locate the fault site without human interaction. The laboratory information was contrasted with the stimulation outcomes to achieve this determination.

"Temperature Coefficient Monitoring System on a Power Transformer Using F.B.G. Sensors," May 2016. Praneeth Kumar, Bajjuri, and Boda Vamsee Krishna Babu suggested Overheating concerns will impair the safe functioning and longevity of an oil-immersed transformer; consequently, the temperature of the windings and oil must be monitored while the transformer is in operation. Temperature sensors for Fiber Bragg Grating (F.B.G.) are fitted to monitor the temperature of the windings, cores, and busbars, as well as the oil temperature at the top and bottom. Temperature data is collected and analyzed over time using an online monitoring system.

Amit Sachan designed a project to acquire remote electrical parameters such as voltage, current, and frequency and send these real-time values over a GSM network using a GSM Modem/phone along with temperature at a power station in another thesis paper published in the IOSR Journal of Electrical and Electronics Engineering titled Microcontroller Based Substation Monitoring and Control System with GSM Modem. Their idea also included an Electromagnetic Relay to protect the

electrical circuits. The Relay can be used to turn off the main power supply by operating a circuit breaker. To read the distant electrical parameters, the user can send SMS (short messaging service) commands. Their device can also automatically communicate real-time electrical parameters.

3. Transformer Failures & Impact

Development of a distribution Transformer Health Monitoring System has been done because the distribution transformer is the most vital asset in any electrical distribution network, and it needs special care and attention. This THMS can monitor the health status of the distribution transformer in real-time aspect. Many transformers are distributed over a small area in present electric systems, and it's complex to monitor the condition manually of every single transformer. So, automatic data acquisition and transformer condition monitoring has been a significant problem [1].

This is used to monitor load currents, over-voltage, transformer oil level and oil temperature, over-voltage, transformer oil level and oil temperature. This system is programmed with some predefined instructions to detect abnormal conditions. Suppose there is any abnormality in the system. In that case, the GSM module will send SMS messages to the designated mobile phone containing information about the exception according to the predefined instructions as it is a wireless communicating system. There is no need for big cables, which are costly. Thus, THMS offers more advanced transformer monitoring [2].

(IoT) to monitor the conditions and control the more significant number of distribution transformers because it is one of the most influential and essential pieces of equipment in the power distribution network. Lora (long-range) technology to monitor and diagnose the state of distribution transformers using specific sensors/devices. This makes it easier to record critical operating parameters such as voltage, current load, winding temperatures, oil temperature, vessel oil level, and silica gel condition for each distribution adapter within 10 km using LoRa modules. This data is sent to the Internet platform objects using the Laura Portal. Power systems are real-time power delivery systems, which means that Energy is generated, transported, and supplied within the required time [3]. The modern power system component includes transformers that raise or reduce voltages as needed, especially transformers that reduce voltage to the level necessary for consumer equipment. Distribution transformers are not only crucial electrical equipment but also more expensive.

Frequent failure of transformers will result in a significant loss of revenue for energy distributors. Generally, continuous distribution transformers are not recommended. However, overload cannot be avoided for a short time. In the case of excess, the additional loss leads to more heat, which affects the burning of winding insulation, causing the final failure of the transformer. Unbalanced loading of the transformer will result in increased copper losses [4]. The temperature of the transformer oil increases with loading, thus increasing the volume of the oil. Distribution adapters work around the clock. The failure of these transformers must cause considerable inconvenience to many consumers and substantial financial losses to facilities. It is, therefore, essential to avoid the disappointment of transformers [5]. The long life of distribution transformers can be guaranteed if they are operated according to the specific conditions that are considered important reasons for the failure of distribution:

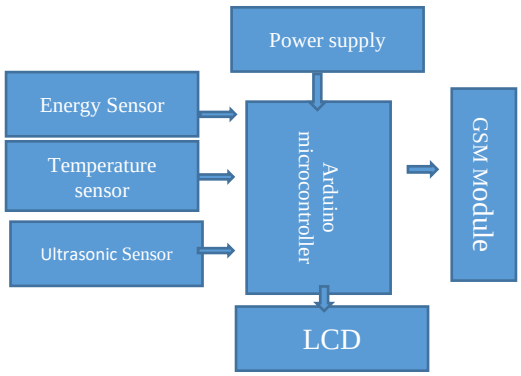

Fig. 1 Block Diagram

Transformers include overload, low-level transformer oil, load imbalance, overheating transformer oil, defects, and inhalation of moisture intake [6].

Using different sensors and Lora WAN technology, an Internet-based solution (IoT) was proposed to improve distribution transformers' control through voltage and current power, oil temperature, file temperature and silica gel status. Lora WAN is a low-power network that supports two-way Internet traffic (IoT), including extensive networks of millions and millions of devices [7]. Council of Arduino Ono. Each digital pin can be used on the Uno panel as an input or output, with different functions such as pin Mode, digital Write, and digital Read.

Software (IDE): Arduino IDE is a program that allows you to write scripts in simple language like the processing language. The download button on the IDE is used to load the chart onto the panel. [8]

4. Major Strengths and Weakness

Different faults cause different failures in different parts. Some are more critical than others; some occur more frequently, while others are difficult to discover. GSM networking helps in the best way of communication, enhancing the process's improvement step. Develop an online monitoring system with many specifications such as information gathering, the best management, case assessment and decision making for engineering.

A single fault not only has an effect on the specific component but on many others in the transformer; therefore, more failure occurs in the transformer from a small mark. The minor fault must not be ignored. Distribution transformers are not only crucial electrical equipment but also more costly. Frequent failure of the transformer will result in a significant loss of revenue for energy distribution. The average operating temperature becomes less than the temperature of contact, which results in overheating the bushing. It will not accept by users.

5. System Modeling and Operation

5.1. Block Circuit Diagram

5.1.1. Block Description

The transformer is a distribution transformer. There are three sensors used in our project, first is the oil and temperature sensor to monitor the temperature in the transformer. There is an opposite direction. If the oil level is lower, the temperature will be high (first faults). The second Sensor is voltage, above or average or below. The third Sensor is the current Sensor to detect the current. All three sensors are analogue and convert to digital, giving the signal to Microcontroller.

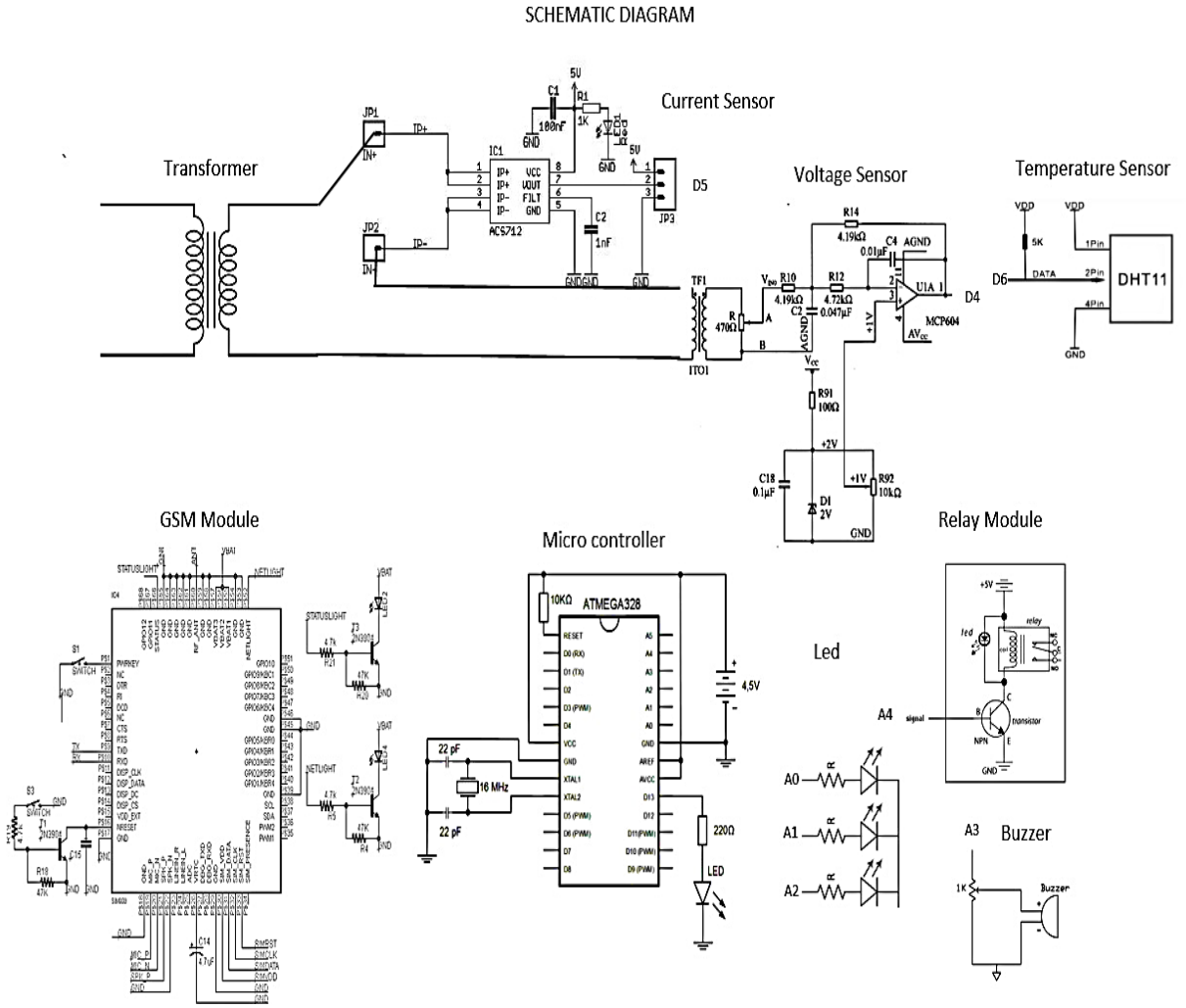

Fig. 2 Circuit Diagram

A microcontroller is the heart of the project. And it understands what the Sensor is doing (C programming). If any abnormal condition or not within the limit, directly send the message by GSM. Also, if there is overload or overheating, we will cut the Relay's power. A light indicator buzzer is a sound for any abnormal condition or fault in the transformer—functional Circuit Diagram.

6. Operation of the Project

When the A.C. is applied to the initial rotation of the power adapter, it can either be deflated or mounted depending on the A.C. power required. In our circuit, a 230 V / 15 V transformer is used to perform the step-down process, where 230 volts A.C. is shown as 15 V A.C. via secondary winding. The correction in the power supply unit is usually done using a solid-state diode. The diode has a property that will allow the electron to flow easily in one direction in the case of appropriate bias. As the A.C. is applied to the diode, the electrons only flow when the positive and negative electrode is negative. Reversing the voltage polarity will not allow the electron to flow.

The four-diode bridge rectifier (4 * IN4007) achieves full-wave correction. The diodes will behave during the negative cycle, and the other two will take place during half a joyous process. The DC voltage shown through the output terminals of the bridge rectifier will be less than 90% of the applicable R.M.S. value. The filter circuitry generally acts as a condenser as a lightning arrester and always follows the unit rectifier. This capacitor is also called a decoupling capacitor or a lateral capacitor. It is used to "shorten" the 120 Hz ripple on the ground and leave the D.C. current to appear at the output. Voltage regulators play an essential role in any power supply unit. The primary purpose of the regulator is to help the rectifier, and the filter circuit provides constant

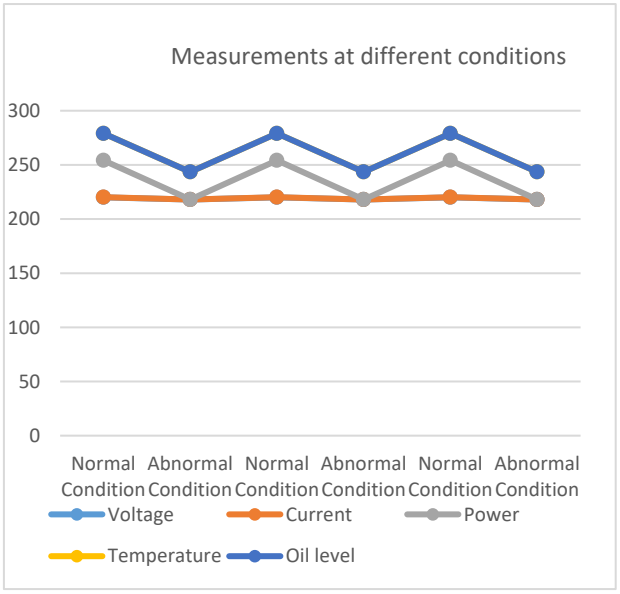

Fig. 3 Output Power - Measurements at different conditions

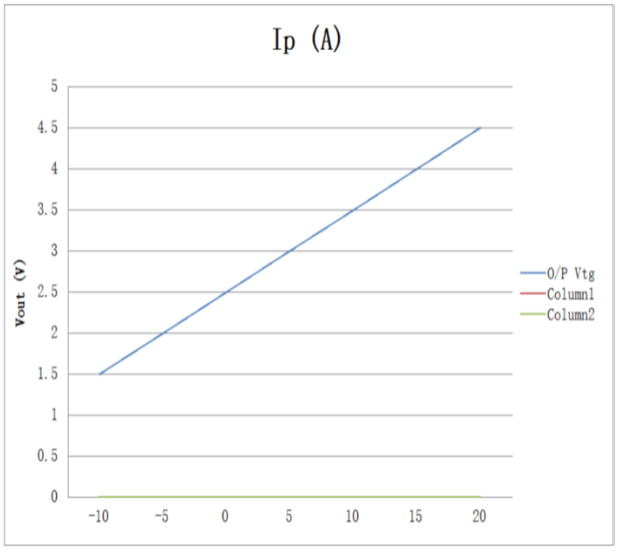

Fig. 4 Output Power

6.1. Primary Work and Simulation

We checked the circuit using a simulation tool called Proteus software. This software is used to know if the designed circuit is working. Another software we used in this project is that one should be familiar with the software to get the perfect layout.

In figure 4, the curve shows the power output (we can get the power by multiplying current with voltage); when increasing the voltage, the current increase. The voltage is a normal condition between 220V to 230V, and the wind is 1.66A. When voltage or current exceeds the limit, the system has an abnormal state (fault) and gets a voltage is 235V and a recent increase to 2A.

7. Results and Discussions

Our system helps monitor the faults and failures in a distribution transformer. Energy Sensor (PZEM004T) sensor measures the Energy consumed. A temperature sensor (D.H.T. 22) measures the ambient temperature. An ultrasonic Sensor is used to measure the oil level. The Relay is used to trip the load in case of any failure or fault, and the Microcontroller is used to perform a predefined task. The GSM module is interfaced with Microcontroller through an RS232 adapter by which it can upload and download SMS messages that contain information related to the transformer status. This GSM module then sends this SMS message to the engineer containing information about the various parameters of the transformer.

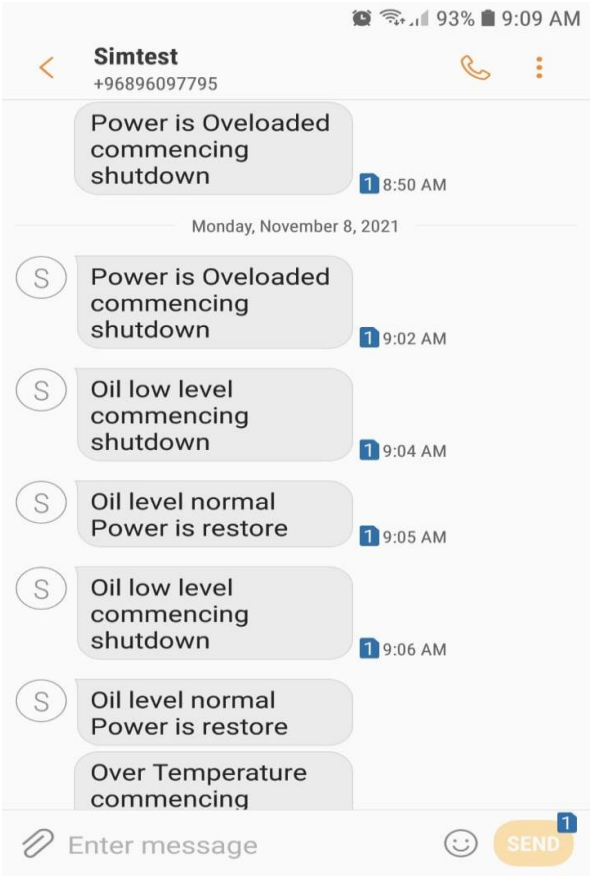

Fig. 5 SMS message

In this project, we started by making a system to help monitor the failures and faults in a distribution transformer. So first, we studied different components needed for this project and selected an economical microcontroller that fulfils our project's requirements.

Table 1. Measurements at different conditions

	Voltage	Current	Power	Temperature	Oil level
Normal Condition	220	0.18	34	24.9	Normal
Abnormal Condition	218	0	Overload	25.5	Normal
Normal Condition	220	0.18	34	24.9	Normal
Abnormal Condition	218	0	0	25.5	Normal
Normal Condition	220	0.18	34	24.9	Normal
Abnormal Condition	218	0	0	25.5	critical

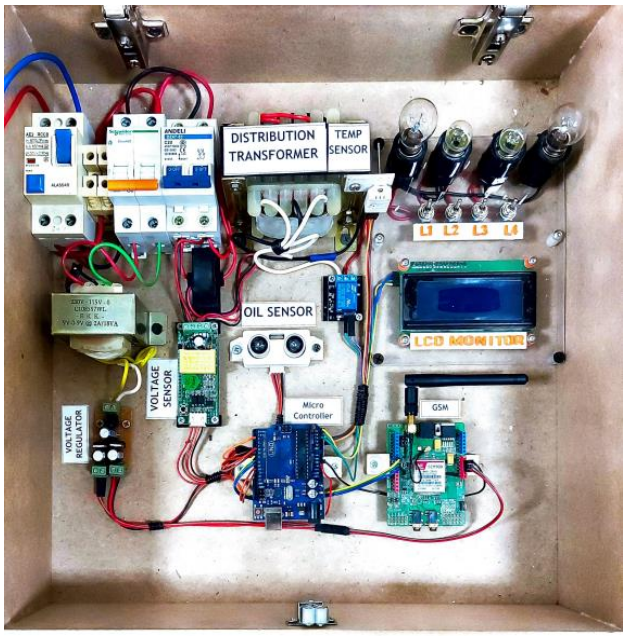

Fig. 6 Final Prototype

ARDUINO is used for this purpose, it is programmed in C language, using Arduino IDE software as a compiler and successfully compiles our code, and then it is successfully loaded to Microcontroller. We interfaced different electronic components like GSM, LCD and Relays to the Arduino on board and tested our hardware. Energy, oil level and temperature are measured for all three phases. Whenever the predefined threshold value was exceeded, in the normal condition, a message was sent to the engineer indicating the type of fault.

8. Conclusion

This project helps monitor the faults and failures in a distribution transformer. We are using three sensors: a voltage sensor to measure voltage, current to sense the current Sensor and a temperature sensor to measure temperature. The Relay is used to trip the load in case of fault failure, and the Microcontroller performs a predefined task. And the GSM module then sends this SMS message to the engineer containing the information about various parameters of the transformer. The voltage between 220 V to 230 V is a normal condition; above or less, this value means the abnormal condition will send a message directly. This system is better than manually monitoring, and the time for preventing failure and loss is also reduced significantly. Also, we need to monitor the parameter to avoid any significant problems.

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