

Monitoring of Transformer and Detection of Faults in Transformer Using IOT and Cloud Computing

Minal Rajput and Prof. Pratibha Shingare

Department of E&TC

College of Engineering,

Pune, India

rajputms20.extc@coep.ac.in, pps.extc@coep.ac.in

Abstract

Transformer is a device which helps in improvement of efficiency and safety of electrical power system by increasing or decreasing voltage levels whenever we needed. As transformer is very important electric device it is necessary to check health condition of transformer by checking various parameters of transformer like voltage, current, etc. so if there are any abnormal change in parameters of transformer, we can easily detect fault present in the transformer to avoid catastrophic effects. It is very tedious job to monitor transformer manually so there is necessity of monitoring transformer in real time. For monitoring transformer in real time, we are using IOT in which various sensors, raspberry pi is used for monitoring and along with this cloud computing is used. Cloud computing is technology which is used for storing and processing data from any computer. There are many different IOT applications that use the open-source platform known as ThingSpeak cloud. Cloud computing is the success of IOT technology. And we are going to add machine learning into this for detecting whether transformer is faulty or not by using various algorithm.

Keywords

Transformer, current sensor, voltage sensor, raspberry pi, and cloud computing.

1. Introduction

Transformer is very essential device in day -to- day life. In every area of our city at least one transformer is present. Basically, transformer is used for stepping up and stepping down the voltage by using the different number of turns within the coil on secondary side. Since current and voltage are inversely correlated, when a stepup transformer is present, current falls and voltage increases when a step-down transformer is present. The failure rate of transformer in India is more than other developed countries. Instead of checking faults or finding the reason behind failure whole transformer is replaced. This automatically affects the economy of our country. Transformer is one of the main components of electricity and big part of investment of government. If a transformer is overloaded, heated by low or high voltage current, or both, its lifespan decreases, which can cause an unexpected breakdown and supply loss for a large number of customers, which has an impact on the dependability of the system. Causes of transformer includes various parameters like overheat, overload, oil leakage, damage seal, broken lead, etc. Transformer has capacity to supply consumers of low voltage with electricity. Consequently, the transformer's operational state is crucial to the distribution network. For a long life, the transformers must be used in rated condition. Transformer overloading and inadequate cooling might result in sudden failure, which can disrupt the delivery of energy to numerous users. The manual monitoring of changes in ambient temperature, load current, and voltage. becomes very crucial task. Causes of Transformer failure are as shown in Figure 1.

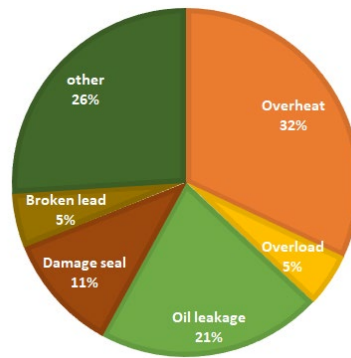


Figure 1. Causes of Transformer failure

There are large number of transformers present in all over country, checking health condition of every transformer manually is very difficult task. We thus require a distribution transformer system to keep track of all crucial parameter operations and deliver timely data to the monitoring system. It offers the important details on the condition of the transformer. By monitoring transformer time to time it helps to use transformer optimally and life of transformer can be increased. This system's primary function is to continuously track the transformer's current, voltage, and temperature. The measured parameters logged into excel file. Technology is becoming faster because of using IOT with cloud computing. These technologies are future which will bring more advantages. The main advantage of using combination of IOT and cloud computing is it solves the problem of storing large amount of data. Without installing any application, we can access our personal files from any computer. It is known as cloud computing because data is found in cloud and there is no need of specific place for accessing. And we are using ThingSpeak for analysing our system. ThingSpeak analyses live data in cloud. We can perform online processing, analysis and managing of data by using MATLAB code.

1.1 Objectives

The main of this system is to monitor the current, voltage and temperature of the transformer in real time. The measured parameters logged into excel file.

2. Literature Review

An Arduino microcontroller and numerous sensors, K. Santhiya et al., 2020 developed a new system to evaluate the transformer's current load, voltage level, oil level, and temperature. The transformer is where this system is placed. System memory is used to store and process output values that were generated by the system. The specified system was constructed with an inbuilt feature to validate the abnormal state of the transformer. The primary objective of the suggested method is to detect the transformer's aberrant condition before any serious breakdown occurs (Santhiya et al. 2020).

In their 2018 paper, D. Sarathkumar et al. offer an IoT-based system for real-time transformer data collection. Data is transferred to the remote location in real time from the temperature sensor, current transformer, and potential transformer. Using ADC 0808, the collected analogue values are sent to 8051 microcontrollers. Direct transmission of this data over TCP IP to a committed IP that displays the information in a chart. The main advantage of this system is that it automatically monitors the transformer's state and updates the webpage with real-time information when the situation is abnormal (Sarathkumar et al. 2018).

Mali Pushpak et al., 2019 provide a brand-new technique for more effectively monitoring transformers and computing oil level, oil quality, transformer temperature, and oil tank outflow. Additionally, it is utilised to automatically locate the afflicted location of the transformer and measure the voltage, copper theft, current flow, and flow levels. Because there is a paucity of human resources and transformers are spread out in different locations, constant monitoring is challenging. There will be a transformer breakdown condition, which results in an unexpected power outage. The main goal of this suggested system is to continuously monitor the transformer without using human labour. When a major issue arises, an IoT technology will be used to send a message to the affected parties and display the error (Pushpak et al. 2019).

A relay-coupled microcontroller-based transformer protection system was developed by D. Mali et al. (2018). Software such as proteus and MPLAB are used to implement the model circuit. This system is more cost-effective and smaller than previous systems.

A wireless transformer monitoring parameter was suggested by authors in Shinge et al. (2016). This system's main goal is to manage and monitor the transformer using an RF module. Both monitoring and controlling may be accomplished using a temperature sensor, microprocessor, and wireless RF transmission. Voltage, current, and temperature are the three variables that the transformer has under constant observation. The tracked data is subsequently transmitted to a distant location. The controller is used to transmit data between the RF and the client.

A GSM method was suggested by Sujatha et al. (2011). The use of this technology with specialised protective measures is successful. These systems, which were created earlier, are communication-based. The potential of GSM technology to increase system dependability amid network outages. The GSM approach accelerates communication while being independent of the distance criterion. To achieve the network's dependability requirements, specialised hardware must be designed. An embedded hardware system gathers data from an electrical sensor system. To provide complete protection throughout the whole transmission and distribution process, the system delivers data from one network to another while monitoring any changes to the transmission's characteristics. Bi-directional messaging is supported by GSM. In this system, an interpreter is employed.

A monitor and control system for distribution transformers that integrates the internet of things was suggested by the authors in Sujatha et al. (2011). The suggested system transmits SMS to a central database for processing using a GSM modem. An online monitoring system is created by the system's usage of a chip microcontroller, a GSM modem, and other sensors. Analog to Digital Converter (ADC) is used to record the measurements of parameters that are listed in the embedded system. At the distribution transformer station, a system is established. The processed parameters are saved in the system memory after processing. If the transformer's readings change in an inappropriate way, mobile phones will get an SMS with information about the new readings.

A sophisticated remote monitoring system was recommended by Sivaranjani et al. (2017). Transformers for distribution are suggested to use this technology. The investment and operating costs are inexpensive since these transformers utilise the GSM communication network. This system is very simple to setup and utilise. A fresh piece of software (DTMAS) has been developed to analyse the voltage imbalance state and is applied to three distinct types of distribution transformers.

A mobile embedded system was proposed by Govind et al. (2017). This technique allows for the monitoring and recording of a distribution transformer's load currents, transformer oil, and environmental temperatures. A single chip CPU, sensor packages, and a GSM modem are all included in the online monitoring system. After the installation was complete, the 8-channel ADC began recording the predetermined parameters at the site of the distribution transformers. System memory is used to process and record the parameters. If any unacceptably disruptive changes are made to the system, a notification of the changes will be delivered through SMS to mobile devices. Additionally, the system uses a GSM modem to transmit SMS to a central database for additional processing.

A history of transformer maintenance was provided by the authors in (Vadirajacharya et al. 2018). This was constructed according to an agenda. because of advances in communication technology. Authorities are informed of a defective transformer thanks to GSM technology. This will assist in resolving the issue before it becomes a deadly situation. In the lab, a microcontroller transformer monitoring kit is produced based on a prototype model and is dependent on a failure analysis. Utilizing digital controller analysis, results are updated on a frequent basis. Using GSM technology, information regarding any issues is given to the operators so they may take the necessary remedial action.

3. Methodology

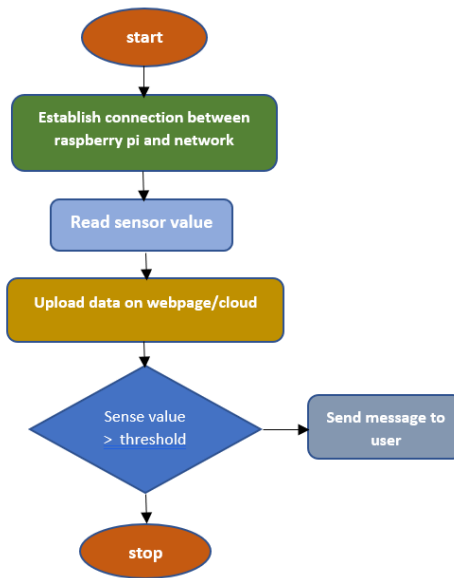


Figure 2. Flowchart of methodology

In our system we have used transformer, which is of 12V, and we have used different sensors for monitoring. In our system current sensor (Figure 2), voltage sensor and temperature sensor are used. We are using raspberry pi for processing. Firstly, we will establish connection between raspberry pi and network. After that sensor will read different values. All the data which is collected by sensors will be processed in raspberry pi. Different readings which are collected by sensors will be displayed on LCD. For recording our data, we are using data logger. Data logger is an electronic device which stores data with built in sensor. Data logger is portable and equipped with internal memory for storage, microprocessor, and sensors. Using cloud computing we will store all information on cloud. We will check whether value is going above threshold or not. If value is exceeding limit, then alert message will be sent to user so that we will get to know about fault present in transformers.

4. Proposed System

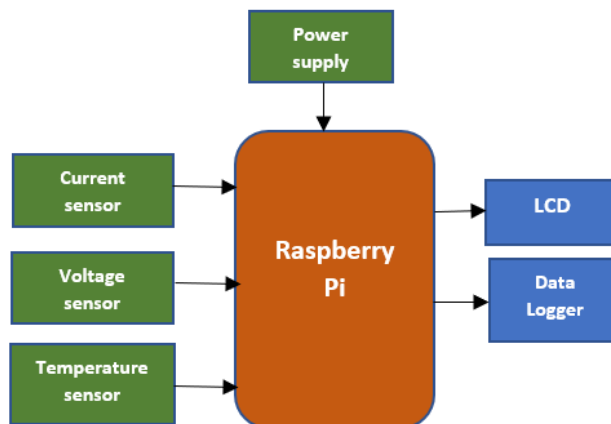


Figure 3. Block diagram of the proposed system

In this system, Raspberry pi is the main component (Figure 3). The temperature sensor is mounted on the transformer to measure the temperature at the current time. A current and voltage sensor is used to measure the solar panel's output current in real-time. The Raspberry Pi monitors these parameters. The data logger system stores the data in the raspberry pi's memory card, which shows all the temperature, current and voltage at a particular timestamp. The component description of the hardware used in this system is explained below. The Raspberry Pi serves as the system's primary component. The solar panel has a temperature sensor attached on it to gauge the temperature at current time. The LDR is used to gauge the brightness of the light. The output current of the solar panel is measured using a current and voltage sensor. The Raspberry Pi monitors these parameters. To obtain a precise timestamp of the time, the RTC is employed. The data logger system records all of the temperature, current, and voltage readings at a certain timestamp and stores the information on the memory card of the Raspberry Pi.

A. Raspberry Pi

The Raspberry Pi is a tiny computer with a screen, keyboard, and mouse. It's a little but capable gadget that allows individuals of all ages to learn about programming languages like Python. An SD card is put into a slot on the Raspberry Pi to serve as the hard drive. The visual output may be viewed on display connected through an HDMI connector. A Raspberry Pi 3 is a tiny computer that can use USB storage to emulate hard drives and consumes very little power. As a result, it's an excellent Home Theater PC. You can run Xbox-style apps via Kodi using special software like OSMC and even operate everything using a remote or controller instead of a mouse and keyboard.



Figure 4. Raspberry Pi 3B+ model

B. Current Sensor ACS712

Current flows of up to 30A can be detected using the ACS712 Current Sensor Module is operated upto 30A (Figure 4 and figure 5).

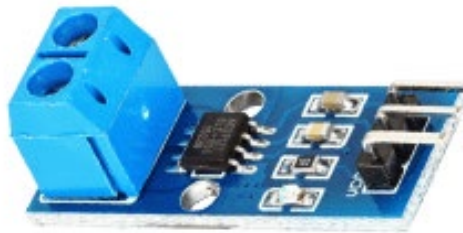


Figure 5. Current sensor ACS712

C. Voltage Sensor ZMPT101B

It is extremely accurate. The ZMPT101B AC Voltage Sensor is perfect for DIY applications that require precise AC voltage measurement through the use of a voltage transformer (Figure 6).

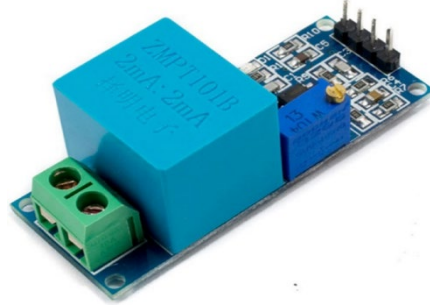


Figure 6. Voltage sensor ZMPT101B

D. Temperature Sensor

LM35 sensors are used for sensing the temperature and an IC ADC0808 is used to convert the data into digital form. LM35 sensor consist of 3 pin's i.e., VCC, GND and output pin. And it has temperature range of -55 to +150°C (Figure 7).



Figure 7. Temperature sensor

E. LCD

This is a basic Alphanumeric display with 16 characters and two lines. Green background with black writing. Uses the HD44780 parallel interface chipset, which is quite popular. The interface code is open source. For connecting this to LCD screen, we need at least 6 standard I/O pins. LED backlight is included. It may be used in both 4 and 8-bit modes (Figure 8).

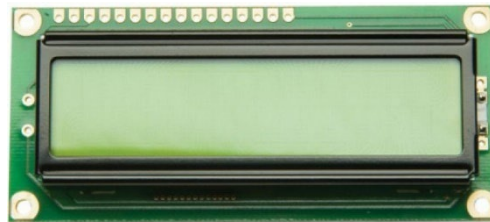


Figure 8. 16x2 LCD module.

4.1 Fault Prediction

To predict and monitor the fault in the dataset best way can be monitoring the changes in the voltage and current values of transformer. Depending upon the ratings of parameter voltage and current ranges can vary. For this purpose, we recoded the readings of 750kv transformer. When the voltage and current ratings go out of the certain limits the transformer fails. According to this the dataset is created for cases of transformer failure and for normal cases values are recorded from the transformer. The dataset is first labelled then used for training machine learning model. The classification of faulty and normal conditions is done with the help of the ML models SVM, KNN and LR. The data is given to the ML algorithms then trained for classifying the faulty and normal conditions (Figure 9 and Figure 10).



Figure 9. 750KV Transformer

5. Hardware of the proposed system

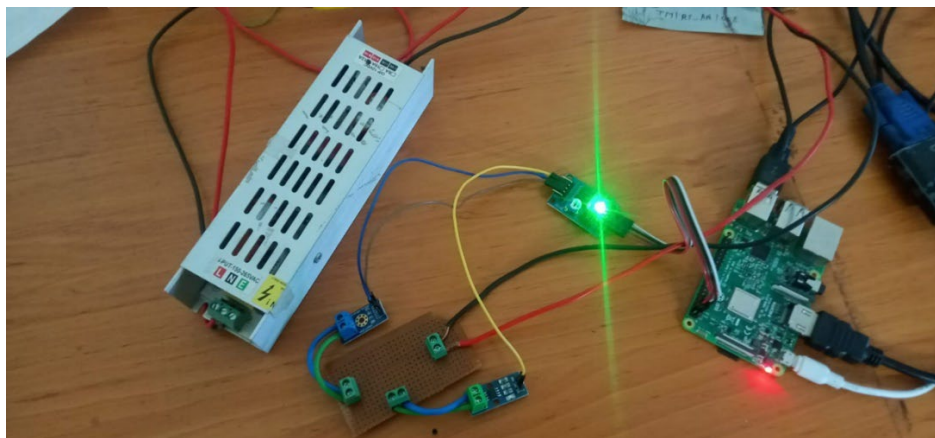


Figure 10. Hardware system of project.

6. Results

6.1 Output on Raspberry pi

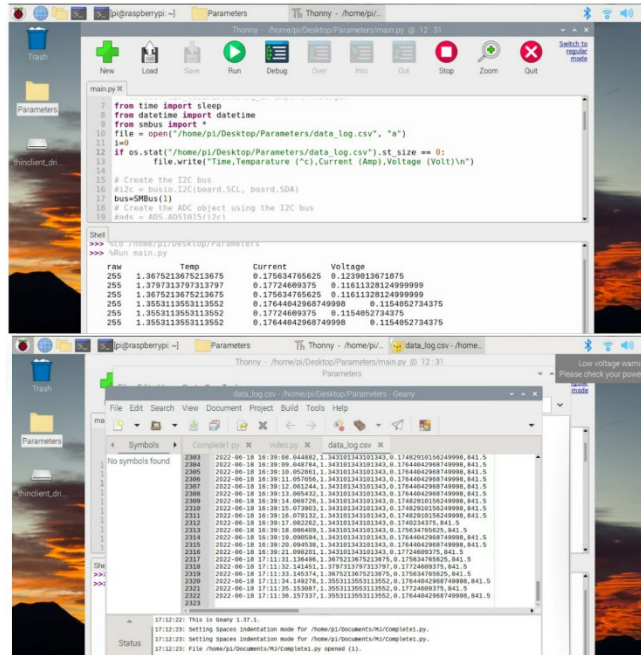


Figure 11. Output on raspberry pi software

6.2 Output on cloud

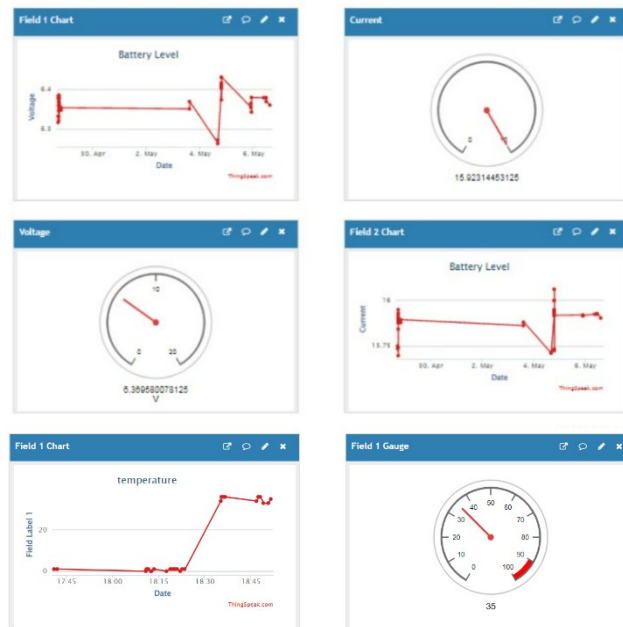


Figure 12. Output waveforms of system using thingspeak

6.3 Bar graph of accuracies of Machine learning algorithms used for fault prediction

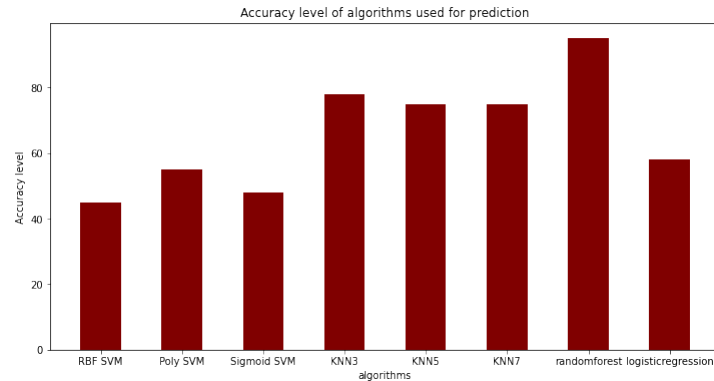


Figure 13. Bar graph presenting accuracies of various algorithms

As Figure 10-13 shows the comparison of accuracy levels of different algorithms. Among all algorithms Random Forest gives more accurate result. Even with the enormous dataset, it operates effectively and predicts the outcome with a high degree of accuracy. Hence, for fault prediction in transformer Random Forest algorithm is more useful.

6. Conclusion

The proposed technique with results has shown that the protection scheme works properly with accuracy, sensitivity of this scheme very high for the abnormal and faulty conditions. Transformer Health Monitoring will help to identify or recognize unexpected situations before any serious failure which leads to greater reliability and significant cost savings. If transformer is in abnormal condition we can know from anywhere. No human power need to monitor the transformer. Details about the transformer are automatically updated in webpage when the transformer is in abnormal condition. With the help of Machine Learning, prediction of faults can be done. Also, while monitoring parameters of transformer, the actual reason which caused the failure of transformer can be found. The data obtained from transformer will be useful for creating effective dataset. In future we can add more parameters of transformer and create more robust ML algorithm to predict the fault in transformer. We can get all information by placing the proposed system modules at every transformer. In future, the machine learning based approach for fault detection in the transformer will be presented. The input to the system would be voltage, current and temperature while output would be the classification of faulty or non-faulty system.

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Biographies

Minal Rajput is currently pursuing her M. Tech degree from College of Engineering, Pune. She has learned different subjects like embedded system, Machine learning, Artificial intelligence, Verilog, Real time operating System during her M. Tech course. She worked on project related with embedded system, Machine learning, Real time Operating System, IOT and cloud computing.

Prof. Pratibha Shingare is presently working as assistant professor in Electronics and Telecommunication department, College of Engineering, Pune. She has experience of more than 20 years in teaching and research and has published more than 13 papers in national and international conferences and journals. She has a good expertise in satellite, industrial controls, earth observation, satellite image processing, satellite image analysis, spatial analysis, automation and process automation control and instrumentation. She is excellent in teaching various subjects like Digital design and verification, Verilog and System Verilog, Machine learning, control systems engineering, communication engineering, electronics engineering, software engineering, Algorithms and Artificial intelligence.