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DESIGN AND IMPLEMENTATION OF REAL-TIME TRANSFORMER HEALTH MONITORING SYSTEM USING RASPBERRY-PI

Priyanka R[1], Chaithrashree N[2], Sangeetha S[3],Bhagyalakshmi [4], Divyashree A[5]

[1] *Assistant Professor, Dept. of ECE, BGSIT, Mandya.*
[2] *Student, Dept. of ECE, BGSIT, Mandya.*
[3] *Student, Dept. of ECE, BGSIT, Mandya.*
[4] *Student, Dept. of ECE, BGSIT, Mandya.*
[5] *Student, Dept. of ECE, BGSIT, Mandya.*

ABSTRACT: *Transformers are one of the most important equipment in power network. As a large number of transformers are distributed over a wide area in present electric systems, it's difficult to monitor the condition manually of every single transformer. So automatic data acquisition and transformer condition monitoring has been an important issue. This project presents the design and implementation of a mobile embedded system to monitor load currents, over voltage and temperature. The implementation of online monitoring system integrates internet of things (IOT) Modem, with single chip Raspberry-pi and sensors. It is installed at the distribution transformer site. The output values of sensors are processed and recorded in the system memory. System programmed with some predefined instructions to check abnormal conditions. If there is any abnormality on the system, the IOT module will send SMS (Short Message Service) messages to designated mobile telephones containing information about the abnormality according to the predefined instructions. This mobile system will help the utilities to optimally utilize transformers and identify problems before any catastrophic failure occurs. This system will be an advanced step to the automation by diminishing human dependency. Thus THMS offers a more improved transformer monitoring.*

INTRODUCTION

Electricity plays an important role in our life. Every moment of our life depends upon electricity. Electricity has several components and equipment helping human to transfer and regulate the distribution according to usage. The most crucial equipment of transmission and distribution of electric power is transformer. In power systems, an electrical equipment distribution transformer directly distributes power to the low voltage users and its operation condition is an important criteria of the entire network operation. The majority of these devices have been in service for many years in different (electrical, mechanical and environmental) conditions. They are the main components and constitute a large portion of capital investment. Operation of distribution transformer under rated condition guarantees their long service life. However, their life is significantly reduced if they are subjected to overloading, heating, low or high voltage/
current resulting in unexpected failures and loss of supply to a large number of customers thus effecting system reliability. Abnormality in distribution transformer is accompanied with variation in different parameters like Winding temperature, Oil temperatures, Ambient temperature, Load current, Oil flow (pump motor), Moisture and dissolved gas in oil, Overloading, oil temperature, load current and ineffective cooling of transformers are the major causes of failure in distribution transformer. When a transformer fails, an adverse effect occurs in the continuity of transmission and distribution systems resulting in increase of power system cost and decrease of reliability in electric delivery. As transformer is a combination of many parts, these all parts must be checked regularly to maintain the transformer in perfect operating conditions.

The IOT based monitoring of transformer health is rather useful as compared to the manual operating system. In case of manual monitoring system, it is not possible to monitor the rise in voltage, rise in ambient temperature, load current frequently. After receiving the message of any deviation, it can easily take action immediately to check any failure of transformers.

In a distribution network system there are many distribution transformers and connecting each transformer with such system can easily figure out faulty transformer from the message sent to mobile, thereby no need of checking all transformers phase current and voltage and thus it can improve the system in less time. Our system is designed based upon online monitoring of key Operational parameters of transformers can provide useful information about the health of transformers which will help the utilities to optimally use their transformers and keep the asset in operation for a longer period.

Most power companies use Supervisory Control and Data Acquisition (SCADA) system for web-based monitoring of power transformers yet amplifying the SCADA system for online monitoring of distribution transformers is a costly suggestion. Distribution transformers are as of now observed physically where a man intermittently visits a transformer site for support and records parameter of significance. This type of monitoring can't give data about incidental over-load and overheating of transformer oil and windings. Every one of these variables can essentially decrease transformer life.

Normal transformer measurement system generally detects a single transformer parameter, for example, control, current, voltage, and stage. While some ways could recognize multi-parameter, the time of acquisition and operation parameters is too long, and testing pace is not sufficiently quick.
A monitoring system can only monitor the operation state or guard against steal the power, and is not able to monitor all useful data of distribution transformers to reduce costs.

The monitoring devices or systems which are presently used for monitoring distribution transformer have some problems and deficiencies. According to the above requirements, we need a distribution transformer real-time monitoring system to monitor all essential parameters operation, and send to the monitoring center in time. It leads to online monitoring of main functional parameters of distribution transformers which will provide necessary information about the health of distribution transformers. This will help and guide the utilities to optimally use the transformers and keep this equipment in operation for a longer period. An online monitoring system is used to collect and analyze temperature data over time. THMS will help to identify or recognize unexpected situations before any serious failure which leads to a greater reliability and significant cost savings.

LITERATURE SURVEY

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.

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 and 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 (Short Message 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.

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.

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.

METHODOLOGY

This paper is a presentation of the design and implementation of Real Time Transformer Health Monitoring System (THMS) through Raspberry-Pi module. Cost effectiveness and remote location will be given priority to this project. In case of software driven system total system requires lot of connection and apparatus and technically skilled personnel. On the other hand, the designed system has less complexity to install and doesn't require any sort of skilled personnel and can be notified remotely. Automatic decision making is the main feature of THMS. Decision making steps are given in a flow chart on Fig. 1, which indicates how the system takes decision.

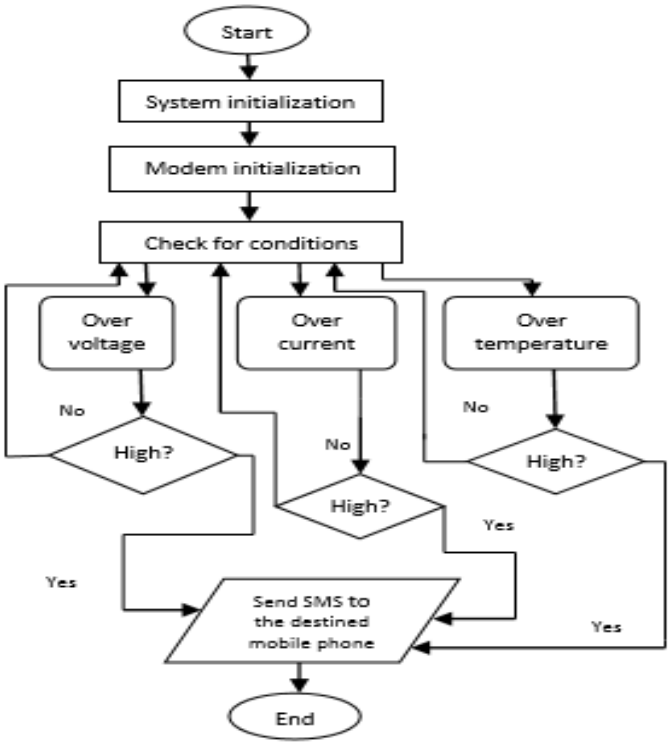

Fig 1.1: Flow chart of THMS system

At first all the sensors and Raspberry-Pi modem initialization occurs. After the initialization process required data are measured from sensors and some common used components simultaneously. Then the Raspberry-Pi starts to compare the incoming values with the saved values in the memory. When there is at least one parameter's value denied the saved value, then the modem takes action to send this message to the monitoring center via Twilio cloud server. If there are no over rated values of current and voltage or the oil temperature is in the predefined value range, then the system jumps back to the testing procedure. This process continues until the decision making logic's output negative. When the decision making logic's output is affirmative, then instantly system will take action for further execution. After sending the information, the loop continues again.

We divided our system into four parts. These are data collector, data converter, data processor and communicating part. The data collector unit is actually different sensor modules which is located at the transformer site. It is utilized to acquire the continuous data from the transformer side. The data converter unit contains an ADC for the conversion process. Then the converted data are processed and measured in the Raspberry chip. In the communicating part IOT module is connected. This module is used for the data communication from transformer to the monitoring center using Twilio cloud server. In the message receiving section an operator can take steps by reading the message about what fault occurs. Thus the Raspberry chip can isolate the faulty transformer before any massive accident.

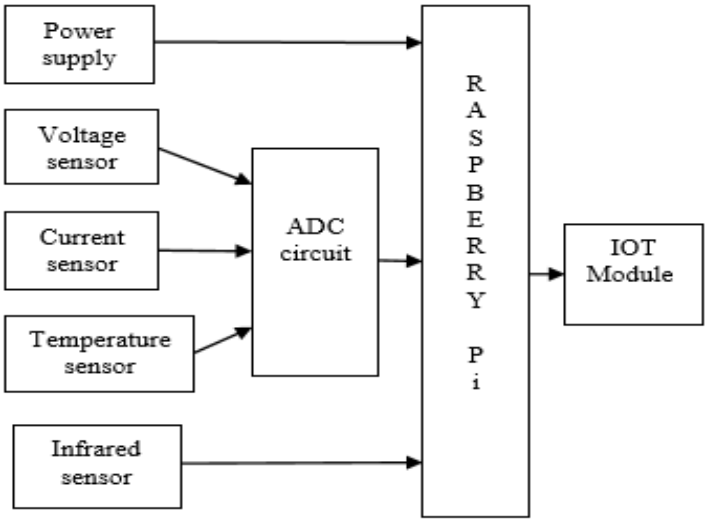

Fig. 1.2: Block diagram of Raspberry-Pi based THMS

As we know, in our power system the transformer is an expensive and important equipment. If it is damaged or tripped due to any reason such as temperature, current or voltage then the whole supply would be switched off. Then the time and money both would be waste, so the real-time monitoring of transformer health is mandatory for supplying smooth supply to the consumer. Here we have designed a system that is called the real-time monitoring of transformer health monitoring system over internet with the help of Raspberry-Pi chip, temperature sensor, current sensor, voltage sensor, and analogue to digital converter. By using this system, or supply company can easily check the instant status of their transformer at their workplace through the internet.

• **Transformer:** In this remote monitoring of transformer /generator health over internet system, the transformer used for step down the 220V ac into 12V ac. It consists of two windings and works on the principle of mutual induction.

• **ADC 0809:** In this system, the ADC 0809 is used for converting the analogue data into digital data for giving the logic signal to the Raspberry-Pi chip. It is powered up with 5V dc. • **Temperature Sensor:** In this system, the temperature sensor is used for sensing the temperature of cross ponding transformer or generator. For this purpose, the LM 35 temperature sensor have been using here. • Voltage Sensor: In this remote monitoring of transformer health over internet system, the voltage sensor is used for sensing the voltage of cross ponding components such as transformer or generator.

• **Current Sensor:** In the system, the current sensor is used for sensing the current of cross ponding transformer or generator. It senses the current in amps and give output in milli amps. It is interfaced with ADC 0809 for giving analogue input.

The advanced THMS includes Raspberry-Pi modem, ACS755xCB-100 current sensor, infrared sensor, memory card, and mobile phone. The THMS continuously measures the line voltage, line current and temperature serially. System reads corresponding values for further calculation for monitoring purpose and does the functions according to the program loaded in it. Twilio server sends data to Mobile Phone. The system starts with establishing a serial communication between the ADC and Raspberry-Pi modem, after a successful communication the system starts to check the parameters. To measure the voltage in primary side a capacitor divider was used and then the divided voltage converted to DC for measurement purpose and then through an ADC channel. As the measured value varies frequently a number of 1000 samples taken and the average value calculated and then multiplied with specific constant to get real AC RMS value.

ACS 755xCB-100 used to measure current which provided an ADC value with proportional to the current through the line measured from another ADC channel. The measured data gives the instantaneous current value. By taking several samples and applying RMS formula to get average RMS current and then recorded.

LM 35 used as temperature sensor which also provides an ADC output as voltage varies few milli volts for every degree Celsius change of temperature. Equation to measure temperature in Celsius unit,

Temp= output_voltage/0.01

After measuring the three parameters, the system checks for the conditioned applied. For transformer condition within the given range system remains checking again. In case of any fault condition Raspberry –Pi sends signal to the service center providing the fault type. After fault clearing the total system again starts to monitor the condition of the transformer.

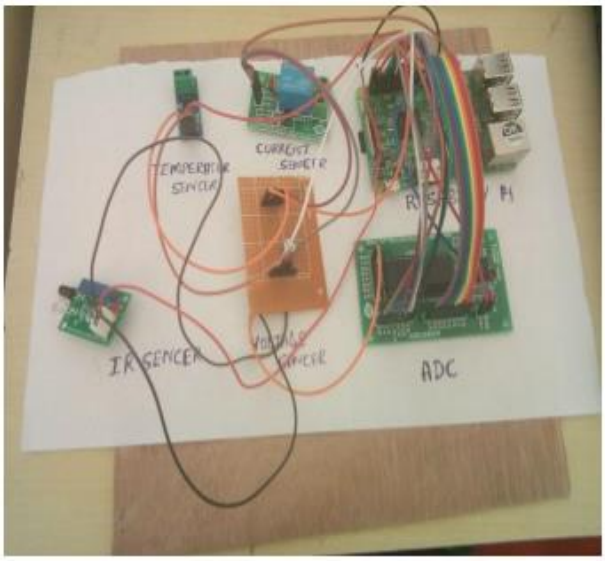

Fig. 1.3: Circuit arrangement of THMS using Raspberry-Pi.

Working Principle: This real-time monitoring of transformer health over internet system works on the principle of hardware components and programme. Suppose we want to monitor the data such as temperature, current or voltage of any transformer, generator, industrial or domestic load then the system is directly connected with these components or equipment's. Then we just switch on the system directly from 220V ac. After that, the current sensor, voltage sensor and temperature sensor sense their cross-ponding data but this data is in analogue from it is converted into digital form through the ADC 0809, which is interfaced with current, voltage and temperature sensors. Then the data is received by the Raspberry-Pi chip through the ADC 0809, then the Raspberry chip display this data at Twilio server account and send this data to the Wi-Fi module which is in-built in the chip. Then we can see this data at our computer or laptop through any dedicated IP (internet protocol) address. This data is displayed at dedicated website in three different charts such as current, voltage and temperature charts.

ADVANTAGES

- The real-time monitoring of transformer health over internet system using Raspberry-Pi could be used for the real-time data monitoring of transformer or generator.
- This system could be used for real time data monitoring of industrial loads and domestic load.
- By using this system, the supply company can easily check the instant temperature, current or voltage of transformer.
- This system is more reliable, cheap and compact as compared to the other systems.
- It is an ARM based system.
- Simpler than GSM, No need of external model.
- Cloud messaging is achieved.
- It can be used for long time without the fear of model damage.
- No limitation for sending SMS (Unlimited messages). It consumes less human involvement and thus reduces the human involvement time.

CONCLUSION

The paper proposes the system of electricity distribution is the delivery of electricity from generating power plants to end users. Distribution system's network carries electricity by the transmission system and delivers its load centers. Thus, it is very essential to have high efficiency, high reliability and high service quality in a distribution system. This study gives remedies from the difficulties of determining fault occurring causes in transformer and it overcomes the drawbacks of previous working methods. The project focuses mainly on the efficiency of monitoring process of the transformer by using wireless communication that eliminates the use of large cables which are of high cost, low reliability and maintenance. The cloud networking helps in better way of communication which enhances the improvement steps in this process. So, use of Raspberry-pi makes the system real time embedded system and aids very much in industry needs. The designed system is connected to a distribution transformer and is able to send abnormal operating parameters information to a mobile device using a Twilio account. The system hardware was constructed from the available components. The experimental results came out as expected.

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