Investigations on the Physical Parameters and Real Time Protection of Distributed Transformers using Internet of Things

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Abstract. This paper presents the design and implementation of a mobile embedded system to monitor load currents, over voltage and transformer temperature. The on-line supervising system integrates global system for mobile communication (GSM) modem, with node microcontroller unit (MCU), sensors and transformers. It was installed at the distribution transformer site. The output values of sensors and transformers were processed and recorded in the cloud using internet on things. System programmed with some predefined instructions to check abnormal conditions. If there is any abnormal value found in the system, the GSM module will send messages to selected mobile at the same time it cut off the supply form the load. Every half an hour it send actual value of current, voltage and temperature of transformer. This mobile system will help the utilities to protect transformer and identify problems before any extremely failure happens. For future analysis it retrieve data from cloud using think speak platform. This system will be an advanced step to the automation by reducing human dependency and increases the reliability of distribution network.

Keywords: Distributed transformer, Real time protection, Internet of Things

1. Introduction

In power systems, distribution electrical device is used to distribute power to the low voltage users directly, and its operation condition is a vital element of the whole distribution network operation. Transformers plays an important role in the efficient transmission of electricity. Regular monitoring and maintenance can make it possible to detect new flaws before much damage has been done. Current systems can provide information about the state of a transformer, but they are either offline or very expensive to implement operation of distribution electrical device below rated condition guarantees their long life. However their life is considerably reduced if they're subjected to overloading, leading to sudden failures and losses provide an oversized variety of consumers so effecting system irresponsibleness. Overloading and ineffective cooling of transformers measures the main causes of failure in distribution transformers. Some major issues like normal electrical device is simply too long and testing speed aren’t quick enough, detection system itself isn't reliable, timely detection knowledge won't be sent to watching centres in time. As it tend to square measure victimization the microcontroller grid known as arduino the on top of mentioned fault will be simply determined. Modern wattage systems encompassing of power transmission and distribution grids carries with it copious variety of distributed, autonomously managed, capital-intensive assets. Such assets comprise: power plants, transmission lines, power transformers and supporting equipment [1]. Power transformers measure at the guts of electrical transmission and distribution system and as competition will increase among the energy sector, thus will the pressure on electrical device producing business to enhance irresponsibleness and scale back prices of transformers. Typically
power transformers have a 20-35 year style life. In follow, an electrical device will reach sixty years of helpful life if it's properly operated and maintained. With the conventional aging, their internal condition degrades, that will increase the danger of failure. Historically, the evolution of those faults was accompanied with preventative maintenance programs combined with regular tests. With release, it's become necessary to cut back maintenance prices and instrument inventories, so there's a trend within the business to makeover from ancient time-based maintenance programs to condition based mostly maintenance [2]. Considering the long service lifetime of an influence electrical device and prevailing use of human judgment (expert), there's a necessity to structure a cognitive content around skilled data whereas continued to form new diagnostic capabilities which might be blocked in it. Hence watching the vital parameters helps in developing each the output generated at the most station and therefore the quality of power being delivered at the client facet. And conjointly capable of recognizing the break downs caused thanks to venturesome conditions [3]. Thus, watching systems offers a chance to record each and every relevant price that's analyzed [4]. This paper intends to provide monitoring system for integrated fault identification of power transformers. The monitoring system will be integrated beside plant controlled system permitting sleek operation and scale back interfaces between completely different systems. The instrumentality is for good mounted on the electrical device and supply 24/7 access to current operational knowledge. The system has no moving elements, hence it desires less maintenance. And conjointly it reduces transformers operational and maintenance value by providing long life time. The system is compact and may be increased for added necessities that will be required in future. The objective is to observe the vital parameters and to tell the ascertained knowledge to the involved official.

2. The transformer connection and its components

2.1 The Connection representation

The figure 1 represented by a block diagram which evaluate different parameters communicating the health of the transformer. Furthermore, the proposed system provides us with a health monitoring system of the distribution transformer which presents us with the data regarding various parameters of the transformer. Additionally, three devices have been used in the proposed system, namely, voltage transformer, a current transformer, and temperature sensor. For the use of arduino, a Wi-fi modem for internet connectivity, and a GSM has been used for sending message to respective mobile number and several sensors has been used.

Fig. 1. The connection representation of the proposed transformer protection system
Figure 1 shows the different modules used in the proposed model. The data received by the cloud was sensed by the sensors. Furthermore, at the same time, data is also being sent to the user’s cell phone via messages. The advantage of having such a system is that if estimation of an unprotected system, system failure can be prevented. In case the overcurrent or over temperature detected the respective transformer was cut off from the load and immediately the messages was send to the user.

2.2 Potential Transformers

Potential transformer or voltage transformer (Fig. 2) was mainly used device in electrical network. This transformer has one primary with two or three secondary sides. The primary and secondary windings are magnetically coupled and it has an iron core part. The primary winding has many copper turns when compared with secondary winding. So any voltage appear on the primary winding was reflected on the secondary windings in direct proportion to the turns ratio or PT ratio.

![Fig. 2. The circuit representation of a potential transformer](image2)

The turns ratio described above was backwards: There are a large number of primary turns and only few secondary turns so that the voltage was stepped down from the high voltage to a low voltage was measured. For example, 13 kV was stepped down to 5V which was measured using standard measuring instruments.

2.3 Current transformer

A current transformer (CT) was a device which provide a current in secondary winding (Fig. 3) was directly proportional to the current in primary winding. They were mainly used in protective relaying in the electrical power industry where they provide the safe measurement of large currents, even in the presence of high voltages. The current transformer (CT) which was almost similar to potential transformer because its steps down the current of a circuit to a lower value and was used in the same types of equipment as a potential transformer.

![Fig. 3. The circuit representation of a current transformer](image3)
In current transformer the secondary coil has more number of turns when compared to the primary coil. So it can able to measure high value of current. When an external load was connected the current transformer always get short circuited. Because the current transformer was designed to withstand low magnetizing current only when an external load was connected means it will increase magnetizing current so the transformer can’t able to with the large magnetizing current So it get short circuited.

2.4 Microcontroller ATmega328P

A microcontroller was a single integrated circuit consists of processor (Fig. 4), programmable input/output peripheral and memory so it was also called a small computer. The processor, memory and input/output pins of the microcontroller can be control. Those pins are called general purpose input output pins (GPIO). Micro-controller has many types based on size, performance etc.

![Circuit representation of ATmega328P microcontroller](image)

Fig. 4. The circuit representation of a ATmega328P microcontroller

In this paper, the arduino uno was used. Compared to normal microcontroller arduino uno has some of extra features so it was very useful to debug and build the work. The arduino uno was based on ATmega328P. Uno micro-controller has 6 analog input pins, 14 digital input/output pins, 6 analog inputs, 16 MHz quartz crystal, a reset button, a USB connection, an ICSP header, and power jack. It was simply connect with USB to the computer or battery or AC to DC adapter.

2.5 Global System for Mobile

GSM Module In the village areas, GSM delivers an ultimate communication network by using the web of mobile communication network. With the use of GSM technology can transmit data with high efficiency, suitability and with low cost. Through GSM the monitoring of distribution transformer health can be done easily. In this work used 2.4 GHz GSM module which was a very precise, accurate and high speed data transfer can be achieved. It works with the baud rates 9600, 19200 etc. It was a transceiver part through which information can be simultaneously transmitted and received. It can support Baud rate of 9600bps, 19200bps, 38400bps and 57600bps when connected to TTL/CMOS. GSM has a capable to with 4 different RF.

2.6 Node Microcontroller unit

Node MCU was a type of development kit which helps to build IoT product and prototype. Node MCU runs on the ESP8266 Wi-Fi SoC. Node MCU hard- ware was based on ESP -12 module. It has only analog input, in our paper almost three analog input was used. So the analog input were connected to the arduino. From the arduino those were transmitted to the Node MCU. And then the data’s were transmitted to IoT platform. It can retrieve the data using thing speak plat- form.
3. Results and Discussion

The output of 220V/50V was connected to the relay. The voltage transformer and current transformer connected serious and parallel to the distribution transformer respectively. Output from the voltage transformer and current transformer were converted into analog signal using rectifier and capacitor. The arduino was capable up to 5V so protection circuit with zener diode were provided. The GSM module TR pin was connected to arduino RX (8) pin and ground pin was connected to normal ground pin. Node MCU RX (receiver) pin was connected to arduino TX (transmitter) pin. Relay Vcc pin was connected to 5V pin and IN (input) pin was to 4 pin of arduino.

Temperature sensor was placed on the distribution transformer. The +5V pin of temperature sensor was to Vin pin, data pin was connected to A2 of arduino and ground was normally connected to ground pin. The analog output of the current positive was connected to A0 pin and negative was connected to ground of the arduino. Similarly the voltage (analog) positive was connected to A1 pin and negative was connected to ground of arduino. The value sensed by the sensor and transformer were transferred to the arduino. From the arduino it was transferred to cloud through the Node MCU.
The GSM was used to send message for every 15 min. If any abnormal condition occurs like over temperature and over current the arduino send signal to the relay and immediately transformer was cut off supply from the load. At the time alert message was also send to the mobile number. Using thingspeak the cloud data were monitored and retrieve in form of JSON, CSV and XML file. The real time model (Fig. 5) and Circuit representation of proposed work (Fig. 6) were shown. The figure 7 was drawn between temperature and time (days). In day 1, initially the transformer was ran at ideal condition and after sometime the temperature was measured by the sensor then it becomes due to transformer was shut down. Then continuously monitor for the transformer for one day. Then for day 2 first half a day the temperature was zero and it gets increase due to the external load connected to it. After removal of external load the temperature value was decreased.

![Fig. 7. Continuous analysis and monitoring of temperature](image)

Day 3, an external load was applied, at the same time the transformer run continuously so the temperature gets increase. Then day 4 the temperature was zero because the transformer was shutdown. Final day 5 a heavy load was connected and transformer run continuously. Entire 5 days
temperature monitoring was represent in the graph. The figure 8 was drawn between voltage and time (days). In one day 1 the voltage was 45V due to 20 watts bulb was connected as external load. Then slowly load was replaced so the voltage gets varied. In day 2, on the transformer the normal voltage of the 230V/50V transformer was occur. By changing the load as DC motor the transformer voltage get varied. In between the day 2 and day 3 the transformer is shut down due to increase in temperature. Then day 3, it entirely shutdown the transformer for half a day. Then day 4, zero watts bulb connected as load so compare with other days the voltage was quite low. Based upon the load the voltage gets varied and the continuous monitoring was represent as a graph.

![Temperature Monitoring Graph](image1.png)

Fig. 9. Continuous analysis and monitoring of current

![Communication Screen](image2.png)

Fig. 10: Communication screen for over current and temperature using GSM
The Figure 9 shows the relation between current in the transformer and the time in days. The point 1 in the graph 0.9A occur due to the external load. Initially the maximum fixed allowable current was 0.7 A so it become overcurrent condition. Because of that the transformer automatically get shutdown it indicates that current was 0A in point 2. Then due overcurrent the load was changed to quite minimum level after that the current become 0.6A in point 3. Next point shows that the overcurrent occur due to add an external load connected automatically the transformer shut down process occur. Similarly the transformer current becomes zero. After the external load was replaced by a small in day 2. So the current value was get decreased. Likewise the load was changed and the current value was also varied. By changing the load the current value was changed and if overcurrent occur the transformer automatically get shutdown. GSM communication has an advantage in such case where the transformer in the remote areas. It sends the message to the person through message which indicates the transformer has some fault in it. At the same time it reduces the manual reading taken by the humans. GSM communication was possible in this work, when the expected faults occur (Fig. 10). Fault No.1- Current level: When device detects high current (set values), it will send the message to set number that “Over Current Occur with that value”; also it will trigger relay for cut off supply. Fault No.2- Temperature: Ambient temperature of Transformer was high or it will be increase it sense through the sensor LM-35and it will send the message to set number that “Over Temperature Occur with that value”; also it will trigger relay for cut off supply.

4. Conclusion

Transformers were among the most generic and expensive piece of equipment of the transmission and distribution system. Regular monitoring health condition of transformer not only was economical also adds to increased reliability. In the past, maintenance of transformers was done based on a pre-determined schedule. Depending upon fault analysis a prototype model of microcontroller based transformer health monitoring kit was developed in laboratory. With the advancement of signal technology now it was possible to receive fault information of transformer through arduino technology remotely to the operator and authorities so one can able to take possible solution before converting fault in to fatal situation. Using digital controller analysis results were regularly updated. During abnormal conditions exceeding specified limit information was immediately analysed through arduino and also to concerned authority for possible remedial action. This type of remote observation of health condition of transformer not only increases the life of transformer but also increases mean down time of transformer there by increased reliability and decreased cost of power system operations.

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