Arduino based Condition Monitoring of Different Parameters of Distribution Transformer

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Abstract

A remote monitoring system for the distribution transformer is developed and built for the monitoring of certain parameters of the transformer such as, temperature, oil level status, fuse cutoff and load variation. The system consists of two units; transformer monitoring unit and data collection unit. The units are based on Arduino in addition to solid state components used for handling sensors, power backup and GSM section for the data communication module. The sensors include, current sensor module, potential transformer, temperature sensor chip and oil level sensor. The system is installed at the distribution transformer site and by measuring above parameters it will help the utilities to optimally utilize transformers and identify problems before any catastrophic failure.

Keywords: Arduino, GSM, Current Sensor Module, Potential Transformer, Temperature Sensor Chip, Oil Level Sensor.

I. Introduction

Power Transformers are the backbone of Electrical power. Any faults or failure occur in transformer either at transmission or distribution points terminate the power supply because the supply of power is in real time. To maintain the continuity of power supply and improve reliability of transformers we need to monitor different parameters of transformer which cause those faults and failures. It can only be done by real time condition monitoring of power transformer which detect incipient faults to avoid catastrophic outrage and also resolve the failures. To achieve that goal GSM based circuit with different sensors controlled by Arduino can be used. These faults and failure consist of fused cut-out issue, abnormal heating, clogged oil piping, low oil level and low insulation resistance etc. Fused cut out issue is the main problem in areas where load is beyond the power level of transformer. When fuse blown up it takes a lot of time by the people to identify that problem and inform the complaint office to solve it manually.

Many researchers have adopted different methods to measure the different parameters of the transformers remotely using different communication techniques. The communication techniques based on Zigbee [1], online monitoring system based on GSM [2], while in [3,4] a mobile embedded system based on GSM have also been adopted. In [5] internet-based Supervisory Control and Data Acquisition (SCADA) system has been used for the monitoring of transformer. Another system that has focused on distribution transformer monitoring and controlling through GSM modem has also been experimented. [6]

Other than the communication techniques adopted for the distribution transformer's health monitoring system, some of the authors have worked on the type of microcontroller that is the heart of the system being used. PIC microcontroller [7], AVR micro controller [8], Arduino micro controller [9], Smart Three-Phase Power Transformer Utilizing Fuzzy Logic Approach [10] are controller used in for the purpose. Apart from the microcontroller, a novel device used to monitor on-line signal for power transformers [11] is adopted. In this technique the measured-data was captured from multi-sensors and stored in the server equipment database.

In this research work a circuit which can identify overload, oil level and oil's temperature of the distribution transformer. The overload condition is shown by the blown fuse, which is monitored with the help of current sensor in addition to an automatic relays. The status is automatically generates a message with the help of Arduino micro controller which is installed at the transformer unit. The unit also sends the generated message to the complaint office, observing unit, using GSM. After the decrease of load, a message will be generated and then send to the transformer unit from the observing unit to turn on the relay for reestablishment of the power supply. The oil conditions which use to damage the transformer, such as low oil level and abnormal heating are also detected by sensors and to save the transformer from the catastrophic outrage the power supply to load will be cut off by turning off the relays and a message of respective fault will be sent to observing unit for further maintenance.

II. General Description of the System

The transformer monitoring system consists of two units, as shown in Fig. 1:

1. Transformer Unit
2. Observing Unit

The transformer unit consists of four types of sensors, which are used to sense the respective parameters and then transmit them to microcontroller. The microcontroller displays the output of the sensors on an LCD also transmits through ZigBee transmitter to the observing unit. The Zigbee receiver receives the data and sends it to the microcontroller which displays it on the LCD. The whole course is real time monitoring of the

different parameters of the distribution transformer. The system is installed at the distribution transformer site and the parameters are recorded with the help of a built-in analog to digital converter (ADC) of the microcontroller which is an 8-channel. The acquired parameters which are sensed by the sensors, are processed and recorded in the system memory and transmitted to the observing unit. The distribution transformer monitoring system (DTRMS) has three exceptional advantages: (i) periodic condition monitoring and maintenance is possible with this system (ii) ad-hoc communication network (iii) catastrophic failure could be avoided before by monitoring the important parameters of the transformer. The main benefits for DTRMS are low installed cost, less time for installation, safe operation and more reliable service.

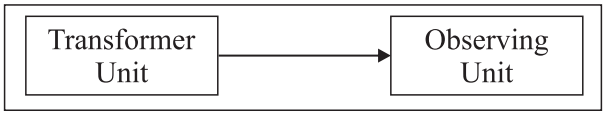

Fig. 1. Basic Working Principle

A. Circuit Structure

i. Transformer Unit

Arduino Micro-controller, Temperature Sensor, Voltage Sensors, Current Sensors, LCDs, Cutoff Relay and GSM modules are the main components of the whole system. The transformer unit consists of 3 phase distribution transformer, current sensors, voltage sensors, temperature sensors, fuel level sensors, Arduino Mega 2560, cutoff relay kit, GSM Module (Transmitter) and LCD. The Table I incorporates the specification of the components. The Fig.2. shows the block diagram of the Transformer Unit.

ii. Observing Unit

The observing unit consists of Arduino Mega 2560, GSM Module (Receiver) and a personal computer. Fig.3. is a block diagram of the observing unit.

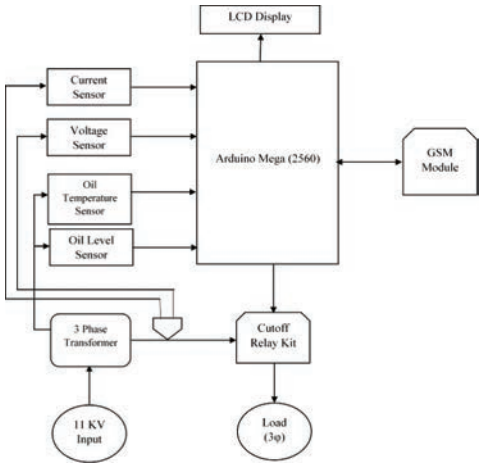

Fig. 2. Transformer Monitoring Unit

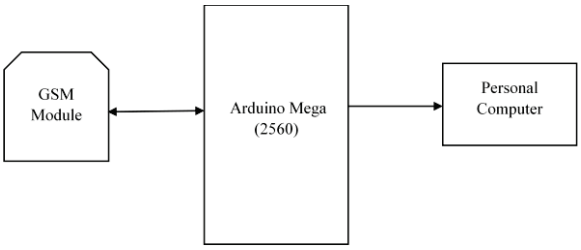

Fig. 3. Observing Unit

iii) Circuit Operation

To measure the oil temperature of the transformer, the temperature sensor (LM 35) is used. While for determining the level of oil in the conservator tank of the transformer, oil level sensor is used. The three phases and one neutral power line of 220 volts are connected as a source to the load. In order to define the phase, every single phase has been named as

TABLE I. Specifcations of Different Components

S.No.	Component	Specifications	
1.	Current Sensor Module	Model No.	ACS712 EL-CTR 30A_A00 96
		Range of current sensor	30 A
		Input for sensor	5V DC
2.	Voltage Sensor	Model No.	Tran12V 6V-B82
		Primary Voltage	220V
		Secondary Voltage	12V
3.	Temperature Sensor	Model No.	LM35
		Accuracy	0.5°C at 25°C
		Range	−55°C to 150°C
		Operations	4 V to 30 V DC
4.	Fuel Level Sensor	Model No.	HPT621 Series Smart Capacitance Level Sensor
		Accuracy	±0.5 % F.S.
		Range	−55°C to 150°C
		Operations	11 V to 33 V DC

Red, Yellow and Blue. The voltage and current sensors are also connected across each phase. For measuring the voltage across each load three potential transformer (PT) are used. When the current exceeds its safe limit the controled fuses are blown. The fuses are control through the relays. The power is calculated from current and voltage by using the relationship.

$$P = V x I \qquad (1)$$

The temperature sensor sends the temperature status of the transformer oil continuously to the Arduino. When the temperature of the oil exceeds 30°C, the buzzer plays the sound to announce the overheat condition, by receiving the command from the Arduino. The Arduino at the same instant commands the relays to cut off the load and also sends the message to the observing unit through the GSM module. When the current exceeds the specific amperage value, relays would cut off power connection to the load. At this condition, a message is generated about fuse cut out to the observing unit.

Similarly the transformer unit sends the different ratings and status of the parameters to the observing unit continuously through the GSM module. The Arduino at the transformer unit also displays the different parameters in the form of rating on the LCD too. In order to apply circuit, various loads having different powers/wattages were connected at the terminals. LCD shows a message of power, current, voltage and temperature ratings. A buzzer is also connected to play a sound of temperature status of the oil. While on the other side of the observing unit the messages are received through the GSM receiver. The data from the GSM receiver is displayed on the computer screen through the Arduino.

IV. Hardware Implementation & Results

Objectives of the project were successfully carried out by implementing the idea/concept practically as shown in Figure 4. The results are of the project are shown in the Table II. Readings of different parameters of transformers are analyzed with connecting variable loads. Voltage, current and oil temperature of the distribution transformer are tabulated in the Table 2. When temperature is equal or exceeds 30°C, buzzer becomes on and play a tone. Action of project/system is taken in the form of Indication. Buzzer is off when temperature ranges below 30°C. Similarly, when system overloaded and current exceed its safe limit, relays cut off the circuit and Fuse is blown out.

The recorded parameters' readings as mentioned above are sent through the GSM module from the transformer unit to the observing unit. The received readings are displayed on the LCD and on the computer. The readings on the computer are also shown in the Figure 5.

V. Conclusion

The outlined objectives in the paper were achieved. The distribution transformer parameters were successfully measured and transferred to the observing unit through the GSM modules. A successful communication was setup between the transformer unit and the observing unit. The two most important aspects of the prototype are the use of GSM, the communication technique used to transfer data from one point to other and the other being the Arduino based system. The first aspect increases the life of the battery and the product while the second one is capable of recording and sending the abnormal parameters of the transformer to the concerned office based on the first aspect.

With modern technology it is possible to monitor a large number of parameters of distributed transformer at a relatively low cost. The challenge is to balance the functions of the monitoring system and its cost and reliability.

TABLE II. Readings of Different Parameter

Readings	Load (Watts)	Current (A)	Voltage (V)	Temperature (°C)	Indication
Reading 1	1 Bulb (100 watts)	0.4	212	35	OK
Reading 2	1 Bulb+ 1 Fan (186 Watts)	0.8	210	27	OK
Reading 3	2 Bulbs +1 Fan (300 Watts)	1.5	180	35	Fuse Blown

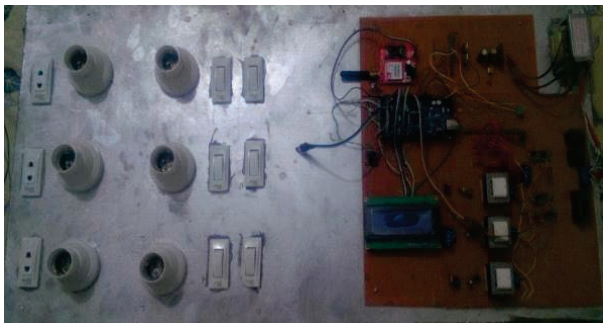

Fig. 4. Transfer Monitoring Unit

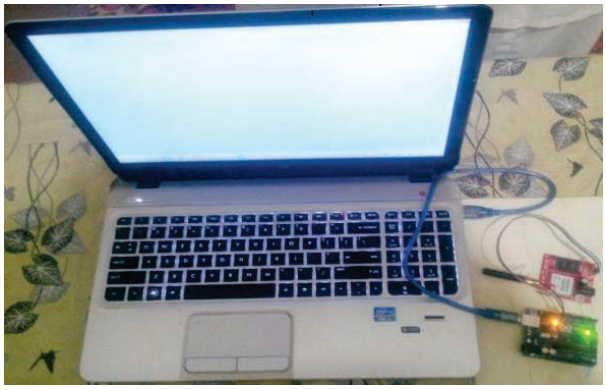

Fig.5. Observing Unit

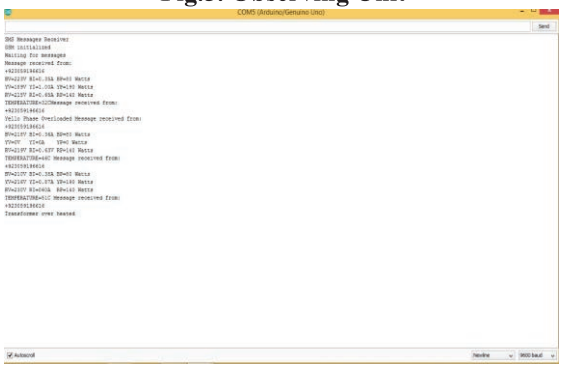

Fig.6. Observing Unit Showing Readings on the Computer

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