Design and Implementation of Real Time Transformer Health Monitoring System Using GSM Technology

Sajidur Rahman, Shimanta Kumar Dey, Bikash Kumar Bhawmick and Nipu Kumar Das
Department of Electrical and Electronic Engineering
Chittagong University of Engineering and Technology
Chittagong-4349, Bangladesh
sajidurrahmaneee@gmail.com, skdshimanta@gmail.com, anjan.13@outlook.com, nipu16@gmail.com

***Abstract*—With the progress and development of national economy as well as power system, reliability and safety issues of power system have been more important. Development of distribution Transformer Health Monitoring System (THMS) has been done in that reason. Distribution transformer is the most vital asset in any electrical distribution network and therefore it needs special care and attention. This THMS can monitor the health status of the distribution transformer in real time aspect. 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 design and implementation of a mobile embedded system to monitor load currents, over voltage, transformer oil level and oil temperature. The implementation on-line monitoring system integrates Global Service Mobile (GSM) Modem, with single chip microcontroller 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 GSM module will send SMS (Short Message Service) messages to designated mobile telephones containing information about the abnormality according to the aforesaid 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. As it is a wireless communicating system, there is no need of large cables which are of high cost. Thus THMS offers a more improved transformer monitoring.**

Keywords—GSM; Transformer health monitoring; Microcontroller; Embedded System; Transformer.

1. 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(as per specification in their nameplate) 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, LTC monitoring, Oil level, Bushing condition [1]. 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, this all parts must be checked regularly to maintain the transformer in perfect operating conditions. 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 [2]. THMS will help to identify or recognize unexpected situations before any serious failure which leads to a greater reliability and significant cost savings. Widespread use of mobile networks and GSM modems, have made them an attractive option both for voice media and wide area network applications.

2. METHODOLOGY

This paper is a presentation of the design implementation of Real Time Transformer Health Monitoring System (THMS) through GSM 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. Fault information will available only in control room. On the other hand, the designed system has less complexity to install and doesn't require any sort of skilled personnel and can be

978-1-5090-5627-9/17/$31.00 ©2017 IEEE

notified remotely. Automatic decision making is the main feature of THMS. Decision making steps are given in a flow chart on Fig.01, which indicates how system takes decision. At first all the sensors, processing controller and GSM modem initialization occurs. After the initialization process required data's are measured from sensors and some common used components simultaneously. Then the microcontroller starts to compare the incoming values with the saved values in the EEPROM memory. When there is at least one parameter's value denied the saved value, then the microcontroller takes action to send this message to the controller cell. If there is no over rated values of current and voltage or oil level is in safer level or the oil temperature is in the predefined value range, then the microcontroller jumps back to the testing procedure. This process continues until the decision making logic's output is negative. When the decision making logic's output is affirmative, then instantly microcontroller will take action for further execution. After sending the information, the loop continues again.

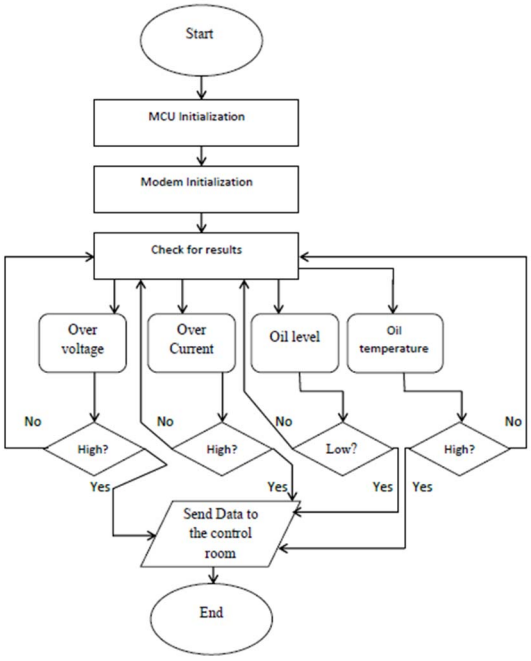

Fig. 1: Flow chart of THMS system

3. SYSTEM OVERVIEW

We divided our system into three parts. These are data collector, data processor and communicating part. In this part we talks about the combined system or control unit for transformer health monitoring system. The system hardware has four hardware units as shown in Fig. 2.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. Then these data processed and measured in the microcontroller. In the communicating part GSM module is connected. This module is used for the data communication from transformer to the control room unit [3] [4]. In the message receiving section an operator can take steps by reading the message about what fault occurs. Thus the controller can isolate the faulty transformer before any massive accident.

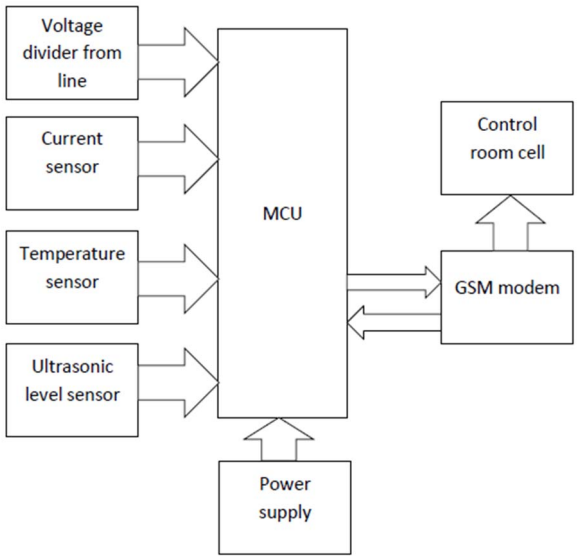

Fig. 2: Block diagram of GSM based THMS system

I. SYSTEM DEVELOPMENT

A. *Interfacing Modules*

The advanced THMS includes Microcontroller, ACS712 current sensor, ultrasonic device, SIM 900GSM module and Mobile Phone. The THMS continuously measures the line voltage, line current, oil level and oil temperature serially. System reads corresponding values for further calculation for monitoring purpose and does the functions according to the program loaded in it. GSM module sends data to Mobile Phone.

The system starts with establishing a serial communication between the microcontroller and GSM modem, after a successful communication the system starts the check the parameters. Baud rate of the established communication was 9600 bps.

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 of microcontroller. 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 712 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 10mV for every degree Celsius change of temperature [5]. Equation to measure temperature in Celsius unit,

$$Temp = output\_voltage/0.01 \qquad (1)$$

Oil level measured using ultrasonic sensor, which provides pulse whose width varies according to the distance between head of oil level. The pulse width of the received signal is measured using TIMER 0. Time measured by counting

overflow then multiplying by the overflow time.

$$cnt = ovr * 256 + tmr0 \quad (2)$$
$$Time = cnt * 0.0000002 * 256 \quad (3)$$

Then the acquired data converted into distance for oil level by using the formula

$$D = Velocity(sound) * time/2 \quad (4)$$

After measuring all four the system checks for the conditioned applied. For transformer condition within the given range system remains checking again. In case of any fault condition microcontroller sends signal to the GSM modem providing the fault type and place by AT command and then modem sends a text message to a given authorized cell no to inform and to take necessary steps and modem does send this repeatedly until the fault is removed . After fault clearing the total system again starts to monitor the condition of the transformer.

AT command to send a text message,

$$AT + CMGS =< number >< CR >< message > < CTRL - Z >$$

$$< CR > = ASCII\ character\ 13$$
$$< CTRL - Z > = ASCII\ character\ 26$$

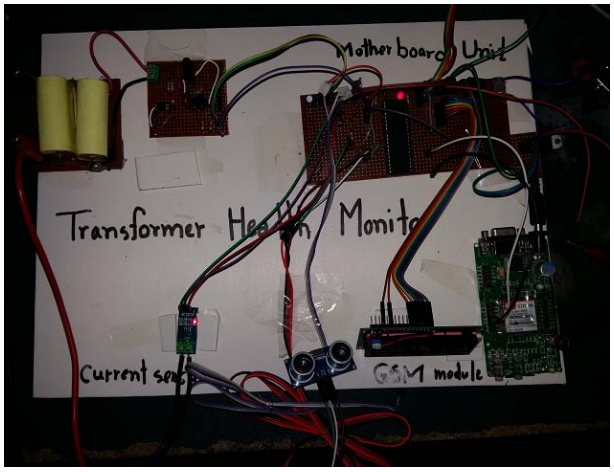

Fig. 3: Practical circuit arrangement of Transformer Health Monitoring System

II. Output Data Unit in Mobile Device

The output information data which is extracted and calculated by microcontroller is then transferred through GSM Module (SIM 900) to desired mobile device. Photograph of output data unit in mobile device is shown in Fig. 4.

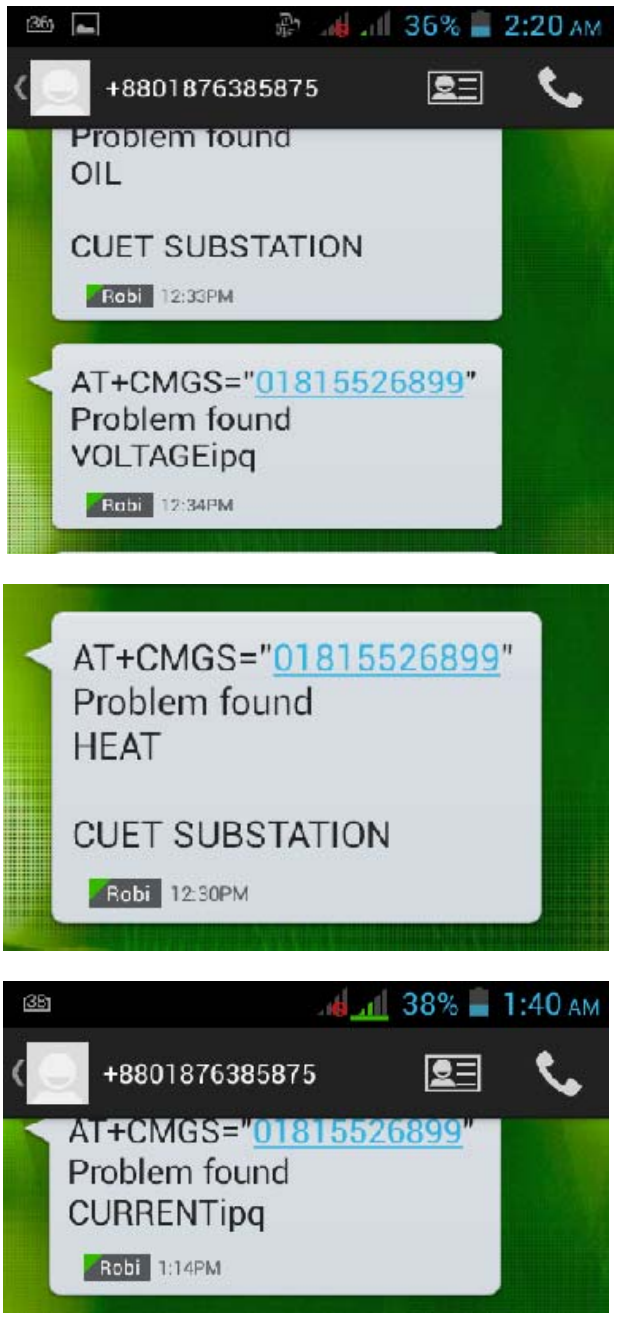

Fig. 4: Output Data Unit in Mobile Device

III. Performance Analysis

Table I and II is produced to analyse the performance of this project. Data is been taken from both multimeter and this project output; where a resistor bank is used as load.

TABLE I. CURRENT MEASUREMENT

Ammeter Reading	Test 1	Test 2	Test 3
1A	1.19A	1.197 A	1.24 A
2.9A	2.91A	2.95 A	3.02 A
3.9A	3.74A	3.89 A	3.88 A
4.8A	4.56A	4.79 A	4.77 A

TABLE II. VOLTAGE MEASUREMENT

Supply Voltage	Test 1	Test 2	Test 3
220V	218.3V	222.5V	215.75V
220V	219.7V	222.7V	217.49V
220V	220.7V	223.5V	217.99V

4. CONCLUSION

The final stage 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[6][7]. The GSM networking helps in better way of communication which enhances the improvement steps in this process. So, use of PIC16F877A microcontroller 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 GSM network. The system hardware was constructed from the available components [8]. The experimental results came out as expected.

REFERENCES

[1] Vivek Landage, Ashish Khsrche, Vadirajacharya. K, Harish Kulkarni, 'Transformer health condition monitoring through GSM Technology", International Journal of Scientific &Engineering. Research Volume 3, Issue 12, December-2012, ISSN 2229-5518.

[2] Anurudh Kumar, Ashish Raj, Abhishek Kumar, Sikander Prasad & Balwant Kumar, "Method For Monitoring of Distribution Transformer", Undergraduate Academic Research Journal (UARJ), ISSN: 2278 – 1129, Volume-1, Issue-3,4, 2012.

[3] Abdul Rahman, Ai Ali, Abdul Khaliq & Muhammad Arshad, "GSM-Based Distribution Transformer Monitoring System", IEEE MELECON 2004, May 12-15, 2004, Dubrovnik, Croatia.

[4] S. Dharanya, M. Priyanka, R. Rubini & A. Umamakeswari, "Real time monitoring and controlling of transformers", Journal of artificial intelligence 6(1):33-42, 2013, ISSN 1994-5450/DOI: 10.3923/jai.2013.33-42.

[5] Zhang Xin, Huang Ronghui, Huang Weizhao, Yao Shenjing, Hou Dan & Zheng Min, "Real-time Temperature Monitoring System Using FBG Sensors on an Oil-immersed Power Transformer", DOI: 10.13336/j.1003-6520.hve.2014.S2.048, Vol.40, Supplement 2: 253-259v, August 31, 2014.

[6] N. Nagaraju & M. S. Kiruthika, "Fault Sensing in a Remote Transformer Using GSM", Vol. 2, Issue 10, October 2013.

[7] Prof. M. S. Sujatha & Dr. M Vijay Kumar, "On-Line Monitoring And Analysis of Faults in Transmission and Distribution Lines Using GSM Technique", Journal of Theoretical and Applied Information Technology, ISSN: 1992-8645, E-ISSN: 1817-3195, 30th November 2011, Vol. 33 No.2.

[8] Sh. Mohamadi & A. Akbari, "A New Method For Monitoring of Distribution Transformers", 978-1-4577-1829-8/12/$26.00 ©2012 IEEE.