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Wireless Communication System for Monitoring Physical Parameters of Distribution Transformers

Namrata Borah[1], Gayatree Sarma[2] and Anwesha Sharma[3]

[1,2,3]Assam Engineering College
E-mail: [1]namrataborah8@gmail.com, [2]gysarma18@yahoo.in, [3]anweshasharma09@gmail.com

Abstract—*This paper discusses a system that has been designed to monitor distribution transformers for their protection against failure. India has the highest record of failure of distribution transformers (around 20%). Usually a distribution transformer is designed to work for about 20-30 years but due to the large number of distribution transformers in most areas, monitoring of each transformer becomes difficult and as a result they last for only 4-5 years. The parameters monitored are oil level in the transformer tank and the oil temperature.The system has been designed with analog sensor circuit governing the oil level and oil temperature. These circuits have been interfaced to a microcontroller for wireless transmission of the detected parameters to the control room. Displays at both the site and the control room have been arranged.*
The detected changes in oil level and oil temperature help the officials at the control room to realize a fault in any distribution transformer in their area of control and take immediate action for restoring the transformer. This will reduce the failure rates by an optimum amount.
The sensor unit has been designed and tested successfully. This system is ready for real-time application. It is cost effective and time efficient in its operation and is very accurate.

1. INTRODUCTION”

The distribution transformers are known to have the highest failure rates in India. The failure of distribution transformers is attributed to many factors such as-

a. Improper installation
b. Prolonged Overloading
c. Unbalance Loading
d. Faulty Termination
e. Improper Maintenance

It has been observed that owing to inadequate monitoring of transformers a high failure rate of distribution transformers is observed which is a big concern for the transformer industry in India. The average operational life of a transformer is between 25 to 30 years; however, transformers in India are known to be recalled for repair as early as in three years. The failure rate of distribution transformers in India is estimated at 10-15 per cent (in stark contrast to the less than 2 per cent in developing countries). Due to large number of distribution transformers in a given region, the physical monitoring of each transformer on a daily basis is not feasible. This results in failure of many transformers due to changes in the transformer oil level and change in the transformer oil properties due to temperatures higher than levels that can be endured by the oil.

For monitoring a transformer we have considered two parameters-

a. The transformer oil level inside the transformer
b. The temperature of the transformer oil

The system designed monitors the oil level and informs the control room when the level drops below a given threshold level required for proper functioning of the transformer. Another system designed informs the control room of the changes in temperature of the transformer oil and the threshold limits in temperature for efficient insulation provided by the oil.

The level of the transformer oil is to be monitored regularly. When the oil level recedes below a given level, the transformer winding is exposed to the environment inside the oil tank. The oil tank may not be completely vacuum and may contain impurities like gases, moisture, dust etc. This will reduce the quality of the winding and may lead to corrosion of the windings.

The temperature of the oil is one of the vital factors determining the insulation properties of the oil. Above a threshold temperature of around 70 degrees Celsius and more, the oil loses its insulation properties due to various reasons. The primary reason of this is oxidation of the oil at high temperatures. Due to oxidation, oil loses its former chemical structure and decomposes into products like gases. The decomposed oil may start conduction through itself. Also at higher temperatures the dielectric strength of the oil recedes and polar components are released that also contribute in the loss of insulation properties.

In the transmitter end the parameters i.e. the temperature and the oil level of the transformer are checked. The results obtained are transmitted by means of a wireless communication system. At the receiver end it is checked and if a irregularity is observed, the alarm goes on. At the receiver end many transformers can be monitored simultaneously.

2. METHODOLOGY

First of all, the analog circuits are designed to monitor the two parameters- oil level which is checked using an IR LED and IR Receiver (TSOP 1738) as a pair of transmitter and receiver, and oil temperature is monitored using a temperature sensor (LM35). On completion of the analog part, the output of both the circuits are interfaced to a microcontroller (PIC18F26K22) which is then transmitted using Zigbee (xbee) module and hence monitored in the control room.

Monitoring of Oil Level

The most crucial part of this setup is the Infra-Red sensor. The design is such that IR transmitter and receiver are fitted two third of the transformer tank .When the oil level drops it receives the IR ray at the receiver end and when the oil level is adequate it does not get IR ray and subsequently alarm is generated.

Level detector circuit comprises of two parts, namely IR transmitter(IR led) and IR receiver(TSOP 1738). The IR receiver can detect IR rays having frequency 38 khz,so for that purpose IR rays of that particular frequency is generated with the help of an astablemultivibrator(using 555 timer). Now,the IR Receiver detects whenever the Infra-Red radiation is exposed. The output of the IR receiver is fed to the microcontroller (PIC18F26K22). Now transmission module, xbee is connected to the pic microcontroller which transmitswhether the oil level is safe or unsafe to the receiving control station.

Monitoring the Oil Temperature:

The oil temperature is sensed by LM35 temperature sensor dipped in the oil. The sensitivity of LM35 sensor is 10Mv per ºC. With increase in temperature the output voltage of the LM35 increases. This voltage is fed to the inbuilt analog to digital converter inbuilt in the pic microcontroller which converts the analog values to digital. The parallel data received is converted to serial data by the inbuilt USART. The Zigbee transmits this data . The Zigbee at the receiving side receives the transmitted data. This data is fed to the PIC microcontroller through pin 18. The serial data received is converted into parallel data by the inbuilt USART . The buzzer is connected to pin 15 of PIC microcontroller. If the sensed temperature exceeds 70 degree C, the buzzer rings.

3. RESULTS AND ANALYSIS

In this chapter we study the results obtained during the various stages of the project .The results and comprehensive analysis of these stages are combined together and compiled together to give the final result. The entire project can be divided into two major parts:

1. The analog part: It comprises of the oil level detector and the temperature sensor circuits.
2. The microcontroller part: In this part the data (the temperature and level) are transmitted to the receiver end by means of a pic18f26k22 microcontroller and xbee s2.

Analog Part

The analog part consists of two parts:

a. The level detector circuit: In this circuit an IR transmitter and receiver is used. At the third pin of IR receiver output is obtained. When the oil level is fine and above the safety threshold, the third pin of IR receiver is high and when the oil level falls (due to leakages or theft) this pin is low.
b. Temperature sensor circuit: In this circuit an lm35 is used as a temperature sensor .The lm35 converts temperature (in centigrade) to voltage (in millivolts). The output is obtained in the second pin of the lm35. With increasing temperature the voltage also increases.

A set of readings along with the linear graph is provided below.

Table 1: Table for variation of voltage at different temperature for LM35

Temperature (mV)	0	28	32	36	48	51	59	62	68	70
Voltage (Celsius)	80	245	298	302	419	480	548	596	654	670

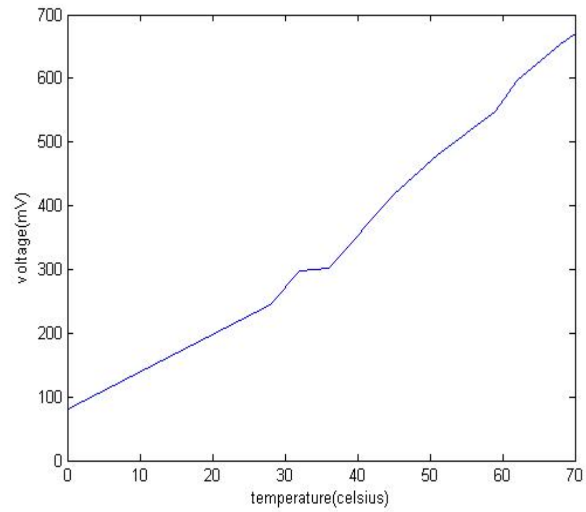

Fig. 1: Voltage vs Temperature graph for the above values in the table”

Microcontroller Part:

The output of the IR receiver is directly fed into the microcontroller as an input. When that input pin is high it sends a flag bit. When that flag bit is encountered in the receiver side a particular pin on the receiver side goes high and displays a particular message "LEVEL SAFE" and when that pin is low it sends another flag bit and drives that particular pin low displays another message "LEVEL UNSAFE" on the LCD.The output of the lm35 is fed to the analog pin of the pic18f26k22 microcontroller. The analog to digital converter (ADC) of the microcontroller converts the voltage (analog) to 10 bit digital value. The increasing hexadecimal and decimal values can be seen increasing with increasing temperature. This can be observed in the graphic terminal hterm. The alarm should be generated just before temperature reaches 70ºC. So for that temperature range the decimal value threshold is noted .When that threshold is crossed a flag bit is sent, otherwise another flag bit is sent. When the flag bit indicating temperature higher than threshold temperature is encountered in the receiver a pin goes high and an alarm is buzzed and when the flag bit indicating low temperature is received drives that particular pin low and an alarm is off.

Thus when irregularities in oil level and oil temperature occurs, appropriate alarms are generated so that necessary measures can be taken and failure of distribution transformers can be averted.

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5. CONCLUSION AND FUTURE SCOPE OF WORK"

Thus a wireless communication system for monitoring the two parameters- oil level and oil temperature has been designed using sensors. IR Transmitter and Receiver (TSOP Receiver) has been used to monitor the oil level and temperature sensor LM35 has been used to monitor the oil level. The two sensor circuits have been interfaced to PIC18F26K22 microcontroller for transmission of the detected parameters using Zigbee RF transmission. 16x2 LCD displays have been used to display the level of oil at a given time and a buzzer alarm has been used for detection of temperature higher than the threshold temperature that the oil can tolerate without disintegrating.

The wireless communication system so designed has been tested successfully. It is ready for real time applications in distribution transformers with harsh oil reservoir environments. It is highly beneficial because of its low cost and time efficiency and meets the challenge of balancing the functions of the monitoring system. The displays and buzzers at both transmitting and receiving ends ensure immediate action at times of distress. The Zigbee transitivity has been used keeping in mind the reduction of complexity.

The system developed monitors two parameters. However many other parameters can be added such as pressure, viscosity, humidity etc. Also the alarm system using buzzers and LCD display can be replaced by more sophisticated software tools that indicate the status of the parameters at every instant of time. This data can be fed to a central server and records over a given time can be stored for future requirements. The Zigbee transmission can also be replaced by GSM transmission for larger area coverage.

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