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Automation Of Distribution Transformer Using Microcontroller -A Survey Approach

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Abstract

Transformers are vital element of the electric power transmission and distribution infrastructure, they need to monitor to prevent any potential faults. Failure in transformer can easily cost several million dollars to either repair or replace, and will also cause a loss of service to customers' revenue until the symptoms is found and repaired. In the past, many innovative techniques have been proposed for the protection of transformers but all those systems lack in providing a robust and sophisticated embedded system which can maintain transformers. This paper proposes the automation of the transformer using microcontroller. Various parameters such as temperature, current and oil level of the transformer are monitored. Any abnormal condition causes the microcontroller to trip the relay and the cause for increase in temperature is also displayed, thus the transformer is protected from severe damage.

1. Introduction

A transformer is a stationary electric machine which transfers electrical energy (power) from one voltage level to another voltage level. Unlike in rotating machines, there is no electrical to mechanical energy conversion. It is a static device and all currents and voltages are AC. The transfer of energy takes place through the magnetic field.

The transformers are having the winding, wound on the core. The flux links with core and the windings of the transformer. The flux of the primary side winding links with secondary winding. This produces the heat because of the losses in the core. The heat will be transferred to the winding and then to the transformer oil. The transformer oil is provided in the transformer for the cooling and better insulation purpose. [3]

Most professionals in the power industry are very familiar with the fundamental principle of how a transformer functions electrically. A transformer is a voltage changing device composed of a primary and secondary winding interlinked by a magnetic core [9]. A three phase power transformer used in transmission and distribution systems shares the same principle. Three phase transformer losses will generate enough heat so that external cooling systems must be added. The thermal aspects of transformer help in understanding the faults.

1.1 Distribution System

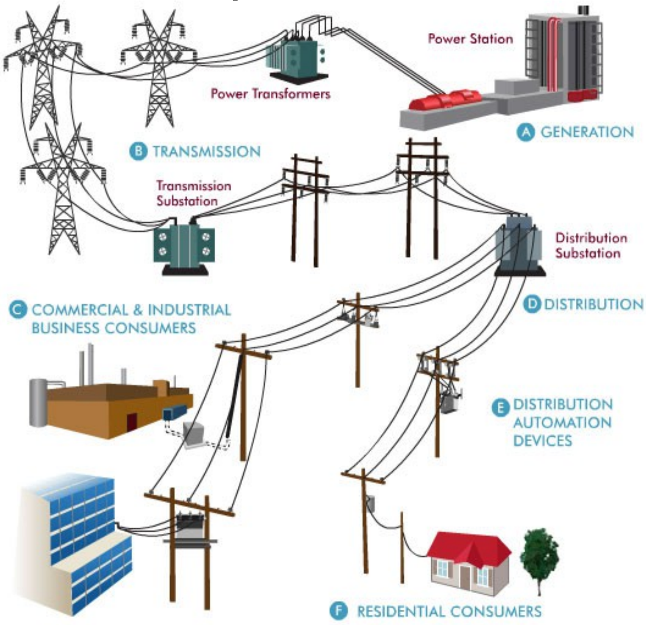

Figure 1

Electric power systems can be divided into two sub-systems, namely, transmission systems and distribution systems. The main process of a transmission system is to transfer electric power from electric generators to customer area, whereas a distribution system provides an ultimate link between high voltage transmission systems and consumer services. In other words, the power is distributed to different customers from the distribution system through feeders, distributors and service mains. Supplying electricity to consumers necessitates power generation, transmission, and distribution. Power starts from the transmission grid at distribution substations where the voltage is stepped-down (typically to less than 10kV) and carried by smaller distribution lines to supply commercial, residential, and industrial users. [11]

1.2 Distribution Transformer

A distribution transformer is a transformer that provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in distribution line to the level used by the customer.

Among different purpose of transformers distribution transformers are one of the most important equipment in power network. Because of the large number of transformers distributed over a wide area in power electric systems, the data acquisition and condition monitoring is an important issue. Since it is an integral part of substation, strategic bottle necks occur if we fail to monitor the transformer. Some parameters of the transformer operation are level of oil, electrical load levels. This study shows the real time monitoring and control of system using sensors for reading the value of different parameters of transformers.

Figure 2

Our project mainly deals with the step down distribution transformer such as the transformer of rating 11KV/230V, etc. The failures of transformers in service are broadly due to: Temperature rise, low oil levels, over load, poor quality of LT cables, and improper installation and maintenance. Out of these factors temperature rise, low oil levels and over load, need continuous monitoring to save transformer life. [10]

During the past years, a number of researches were undergone with the help of microprocessors and controllers for continuous monitoring of parameters like voltage, current and temperature fluctuations in the distribution transformers at the substations. The level of voltage and current at the substations may vary drastically due to increase in temperature eat the distribution transformers. It is capable of recognising the breakdowns caused due to overload, high temperature and low level of oil. If the increase in temperature rises higher than the desirable temperature, the monitoring system will protect the distribution transformer by shutting down the unit. [1]

The adaptability of a transformer enables it to have a wide range of applications. One of the most important parameter that has an influence on the transformer insulation is the temperature. [7] Thus control is required. Generally, control has 3 parts: measuring, computing, setting. During evolution machines became more powerful, quicker, more precise, thus human control doesn't fit their tasks. It became necessary to control machines by other machines. This control is the automation.

As discussed earlier, maintenance of the transformer is one of the biggest problems in the electricity board (EB). During strange events for some reasons the transformer is burned out due to the overload and short circuit in their winding. Also the oil temperature is increased in the level of current flowing through their internal windings. Therefore, we are proposing the automation of the distribution transformer from the EB substation. In this automation, we consider the current, temperature and oil level as the parameters to be monitored as the transformer shows its peak sensitivity. Hence, we design an automation system based on microcontroller which continuously monitors the transformers.

The temperature control of transformer can be achieved by manual operation and secondly through software. The manual process is tedious and time consuming, but the software method gives spontaneous and accurate results. We consider three inputs while implementing this model. They are temperature, load and oil content. [8]

The reason for using AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (EPROM).The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control application.

2. Earlier approaches

In other papers a design was proposed to develop a system based on micro controller that is used for monitoring the voltage, current and temperature of a distribution transformer in a substation and to protect the system from the rise in mentioned parameters. Providing the protection to the distribution transformer can be accomplished by shutting down the entire unit with the aid of the Radio frequency Communication. Moreover the system displays the same on a PC at the main station which is at a remote place. Furthermore it is capable of recognizing the break downs caused due to overload, high temperature and over voltage. The design generally consists of two units, one in the substation unit, called as transmitter and display unit, and another in the Main station called as controlling unit. The transmitter and the display units in the substation is where the voltage, current and temperature are monitored continuously by AVR microcontroller and is displayed through the display unit. An RF transmitter is used for transmitting the signals that are obtained. In general, the proposed design is developed for the user to easily recognize the distribution transformer that is suffered by any open or short circuit and rise in temperatures. The ultimate objective is to monitor the electrical parameters continuously and hence to guard the burning of distribution transformer or power transformer due to the constraints such as overload, over temperature and input high voltage. If any of these values increases beyond the limit then the entire unit is shut down by the designed controlling unit. [1]

Cooling control of distribution transformers is traditionally provided by a winding temperature indicator (WTI) that is based on a measurement of the top oil temperature and a simulation of the winding hottest spot temperature. This method has some drawbacks; the methods used by classic WTI can indicate a lower temperature by more than 10 degrees Celsius even if they are properly adjusted for the steady state condition. Now that transformers are used closer to their rated values and overloading is more frequent, more accurate measurement of temperature is required. [2]

However, recently a method for the above, fibre optics sensor control temperature control is used, Fibre optic temperature sensors have been available for measurement in high voltage transformer. The main problems with fibre optics sensors are that they must be installed at the winding manufacture stage and the location of the hottest spot must be known to the manufacturer. The installation of the fibre optic probe and the handling of this long fibre during manufacturing are certainly challenging to avoid sharp bend that could break the optical fibre. [2]

Also there was a system consists of a microcontroller based circuit, with solid-state components for handling sensors, power back-up, real time clock and data communication module which based on ZigBee protocol. [10]

Another work deals with the problem of magnetising inrush current phenomenon in transformers and describes the design of a robust time delay relay which can be used to control the inrush current into transformers. Earlier to avoid inrush current, the transformer is to be connected to the line when the voltage is going through its peak. This requires a point on wave switch which makes the switching equipment costly and cannot be adopted. Also, a mechanical or electromechanical contactor is used to connect the transformer to the line in practice and there is no control on the instant of switching. Another way is to use NTC thermistor in series with primary. This NTC thermistor will offer high resistance at the beginning of switching and limit the inrush current. After a short time thermistor resistance decreases to a low value due to self-heating and does not affect normal operation. The NTC thermistor solution is practicable for small transformers. [4]

Also another work presents design and implementation of a mobile embedded system to monitor and diagnose condition of transformers, by record key operation indictors of a distribution transformer like load currents, transformer oil, ambient temperatures and voltages. The proposed on-line monitoring system integrates a Global Service Mobile (GSM) Modem, with a solid state device named PLC (programmable logic controllers) and sensor packages. Data of operation condition of transformer receives in form of SMS (Short Message Service). [6]

For monitoring transformer many methods have been adopted. In earlier works oil level, float level, temperature level, overload has been measured manually. These levels should be checked periodically by the operating personnel which will be tedious and inefficient way of monitoring. Other works include capacitor sensor which can sense the dielectric signals for detecting moisture level inside transformer pressboard.

Thus, the earlier works shows various protection measurements of transformers and power supply but all those systems lack in providing a robust and sophisticated embedded system which can maintain transformers and improve the transformers life.[5]

3. Proposed Design

In this paper we have proposed a design of a system based on AT89C52 microcontroller that is used to monitor and control the temperature oil level and current of distribution transformer, the proposed system which has been designed to monitor the transformers essential parameters continuously monitors the parameter throughout its operation. This claims that the proposed design of the system makes the distribution transformer more robust against some key power quality issues which make the temperature, current to peak. Hence the distribution is made more secure, reliable and efficient by means of the proposed system. Also, it is cost effective, of small size, power consumption is less, robust and less time consuming.

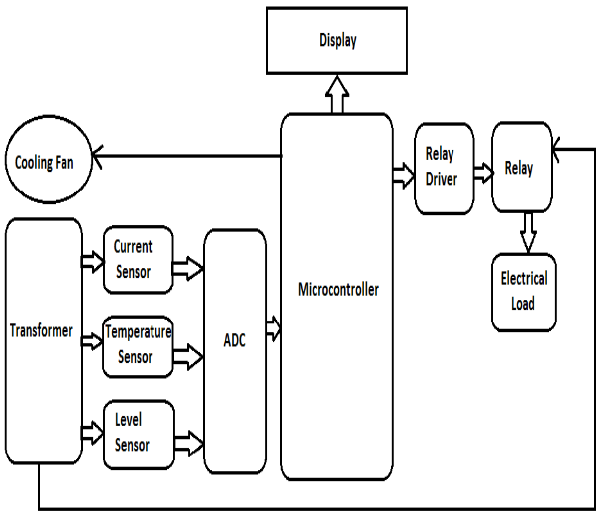

Figure 3

BLOCK DIAGRAM OF PROPOSED DESIGN

3.1 Design Procedures

The design procedure for proposed microcontroller based system is described as follows:

- Define the interfacing parameter for LCD and Data Registers.
- Assign a value for circuit elements such as relay and fan.
- Initialize the input and output ports of the microcontroller.
- The function defined for capturing the current, oil level and temperature values are called and executed.
- The displaying function is called, the parameter values are displayed.

The controller program is based on comparing the parameters continuously and displays the cause of abnormality in the display unit .The procedure stated below are perform and parameter values are captured to check whether transformer is operating under a safe condition.

- The microcontroller is connected to LCD and transformer is connected through their respective Interfacing IC's. The appropriate operation of interfacing are maintained and carried out with the help of data processing unit. Interfacing parameters are defined in order to initialise the communication between the microcontroller and the peripheral devices. The values of parameters are to be set i.e temperature, oil level and current.

- The temperature is increased by the set value .The analog voltage for temperature sensed by the temperature sensor LM35 is converted into digital signal with the help of ADC 0809, and microcontroller AT89C52 turns on the fan.
- After that controller checks the oil level. If its level is less than set value it cut off the load and display "low oil level" on LCD .If oil level is proper than it checks the current.
- The analog Current signal from current sensor is converted to analog voltage signal using Precision Rectifier and ADC 0809 converts this analog voltage signal to its digital form. If the current is greater than set value then it cutoff the load and displayed as "over current" on LCD.

3.2 Case study

In order to analyse the efficiency of a microcontroller based monitoring system, we applied three various types of load at the output of the distribution transformer and transformers operating parameters were calculated. Then the received parameters were analysed with the transformers rated values.

Case (1): The transformer was made to work under usual condition and no additional load is applied to the transformer. During these conditions the received parameters (Oil level, current and temperature) were below the rated values of the testing transformer, thus confirming safe operation of entire unit. Under this condition, our monitoring procedures were only executed and the relay was kept in the closed position. The temperature of transformer was normal, the current and the oil level were very efficient and maintained normally.

Case (2): When the small increase in the load was applied to transformer. It was observed that there was small increase in transformer temperature. The cooling fan is turned on by microcontroller. This stage also confirms the safe operation of substation unit with a lower degree of risk.

Case (3): In this case a heavy load was applied to the transformer and parameters were measured. Since the applied was higher than the testing transformers rated load the value of the temperature increases to a greater value.The temperature value is found greater than the set value, microcontroller cuts the supply for the electrical load through relay.

The performance of the proposed system has been examined with three various types of loading which has been added to the transformer. From the experimental observations it can be understood that, the proposed system monitors and controls the transformer in an efficient manner. When a sudden rise in temperature sensed by the system while monitoring the transformer, it directs to cut the electrical load and thus it guards the distribution transformers from many serious damages.

4. Conclusion

The earlier transformer monitoring methods were quite imprecise and maintenance of the transformer is still one of the biggest problems. A system based on microcontroller that is used to monitor and control the temperature, oil level and current of distribution transformer, makes the distribution more robust, reliable and saves huge economic losses due to replacement of transformers.

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