MICROCONTROLLER BASED AUTOMATIC CONTROL OF GENERATING TRANSFORMER 250 MVA COOLING SYSTEM

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ABSTRACT

The NLC India limited is a successful organization which has served its purpose of electrical generation for more than 50 years. Though generation is done for its maximum possible capacity, there are many factors which affect the efficiency of transformers. The main drawback is its loss of efficiency due to the heating up of the winding. Ignored to reduce this heating effect, cooling systems are implemented by means of contactor logic. Since the contactors are made up of metal, there is a possibility of arcing which can further increase the temperature. The proposed system overcomes this drawback implying the same control by using a microcontroller. The controller used here is arduino uno and the cooling system primarily requires the sensing of the oil temperature and winding temperature. The system gives an alert when the oil level goes low. If the temperature of the winding increases uncontrollably, provision to trip the transformer is also implemented.

INDEX TERMS: Generating transformer, rduino uno, microcontroller, cooling fans, oil pumps, oillevel, reservefans, reserve pumps, trip.

I. INTRODUCTION

A Transformer is a static device consisting of two or more windings which by using an electromagnetic induction, transforms alternating voltage and current into another system of voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power. The principle of a Transformer can be explained by means of Faraday's Law of Electromagnetic induction which states that "Electromotive force is induced in a closed electric circuit whenever there is change in magnetic flux linkage of that circuit and the induced emf is proportional to the rate of change of flux linkage." Transformers are the most highly efficient electrical devices having full load efficiency between 95% to 98.5%. As a transformer being highly efficient, output and input are having nearly same value, and hence it is impractical to measure the efficiency of transformer by using the ratio of output to input. But there are losses which reduce this efficiency and one the main losses are due to the heating of transformer. So in order to improve the efficiency effective cooling system becomes essential. A contactor is an electrically controlled switch used for switching an electrical power circuit. A contactor is controlled by a circuit having lower power level when compared to the switched circuit, such as a 24 V coil electromagnet controlling a 230 V motor switch. Without adequate protection to the contacts, the occurrence of electric current arcing causes a significant degradation of the contacts, which suffers significant damage. An electrical arc occurs between the two contact points when they undergo a transition from a closed to an open or from an open to a closed. The break arc is typically more energetic and thus more destructive [4]. In order to improvise the cooling, the proposed system can be implemented.

II. LITERATURE REVIEW

The current cooling system has contactor for its operation. A contactor is an electrically controlled switch used for switching an electrical power circuit. The contactor has three components that includes contacts, electromagnet and the enclosure. When current passes through the electromagnet, the magnetic field is produced. It attracts the contactors moving core[1]. The electromagnetic coil initially draws more current until its inductance increases when its metal core enters the coil. The moving contact is propelled by the moving core, the force developed by the electromagnet holds the moving and fixed contacts together[2]-[3]. When the contactor coil is de-energised, the gravity or a spring returns the electromagnetic core to its starting position and then opens the contacts.

III. ARDUINO UNO REV3

The Arduino Uno Rev 3 by Arduino is a cheap development microcontroller board for 25USD$. It consists of a 20MHz ATmega328P processor allows Uno Rev 3 to be small and developer friendly [2]. It consists of 32 KB of In-System Self-Programmable Flash program Memory. It also has 1 KB EEPROM and 2 KB Internal SRAM. It is powered by a 5-volt source like a USB port and it also has 14 digital input/output pins of which 6 of its pins can be used as PWM outputs,6 analog inputs, 16 MHz quartz crystal, USB cord, a power jack, ICSP header and a reset button. It contains everything needed to support the microcontroller.

Figure 1. Arduino Rev 3 Microcontroller Board

IV. CONTROLLER BASED COOLING SYSTEM

The present monitoring technique used in the cooling system of generator transformer (GT1) in the TPS-I expansion is based on contactor logic. During high temperature, since the contactors are made of metal, there is a possibility of arcing which can further increase the temperature. The proposed system overcomes this drawback by implying the same control by using a microcontroller. The microcontroller used here is Arduino UNO for its simplicity and ease of programming. The cooling system primarily requires the sensing of the oil temperature and winding temperature constantly. Depending on the temperature range of the winding the cooling is provided. The output power of the transformer drastically changes with the type of cooling. The transformer dealing with this system is of 250MVA capacity and it is also capable of operating at 125 MVA and 175 MVA. The microcontroller is programmed such that the fans start in auto at 60° C of winding temperature. Generally, we use winding temperature for the control of cooling system because the transformers heating is primarily experienced at the winding even before the oil gets heated. We use two sets of five fans each, in which one fan of each set is kept as reserve. During high temperature, two of the fans get operated. If the temperature doesn't reduce to operating range, then the reserve fans come into action. Even if the running fans fail to operate, then the reserve fans start tofunction.

In our proposed prototype, only two of the fans are shown for simplicity. If the temperature of the transformer further increases, this mainly occurs in case of faults in the transformers, the pumps are provided for cooling purposes. Two pumps namely A and B are kept to serve this purpose. When the temperature increases beyond 70°C, the pump starts to operate. If pump A fails to operate, then pump B starts to function. Usually, only one pump is operated.

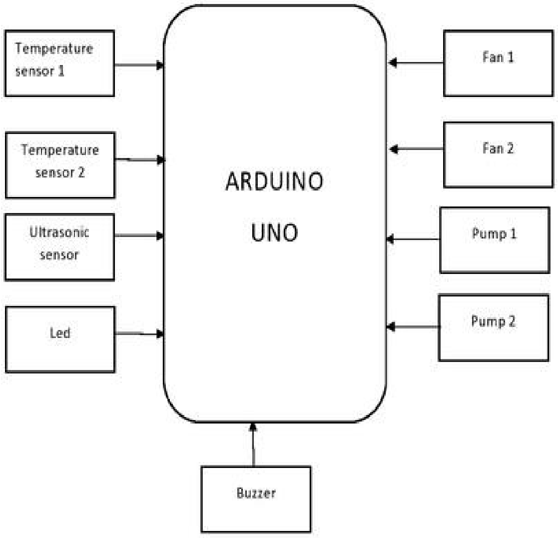


Figure 2. Block Diagram

A flow meter is implied to check whether the pump is functioning properly or not. If the pump doesn't function, the flow meter senses it and sends feedback which causes the pump at the reserve to operate. The transformers give a warning alarm if the winding temperature reaches 85°C. Proper steps are taken to prevent transformer from getting tripped, but if winding temperature reaches 95° C,the transformer gets tripped. But this condition is very miserable because the transformers are the only equipment which doesn't have any reserves due to its high cost. Only to avoid such scenarios, the cooling system is given much importance.

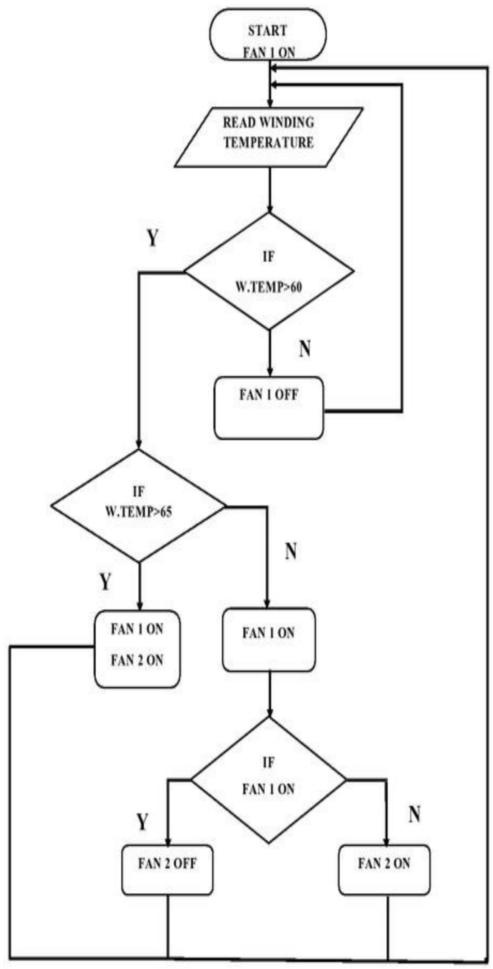


Figure 3: Flowchart 1: Temperature ranges for fan

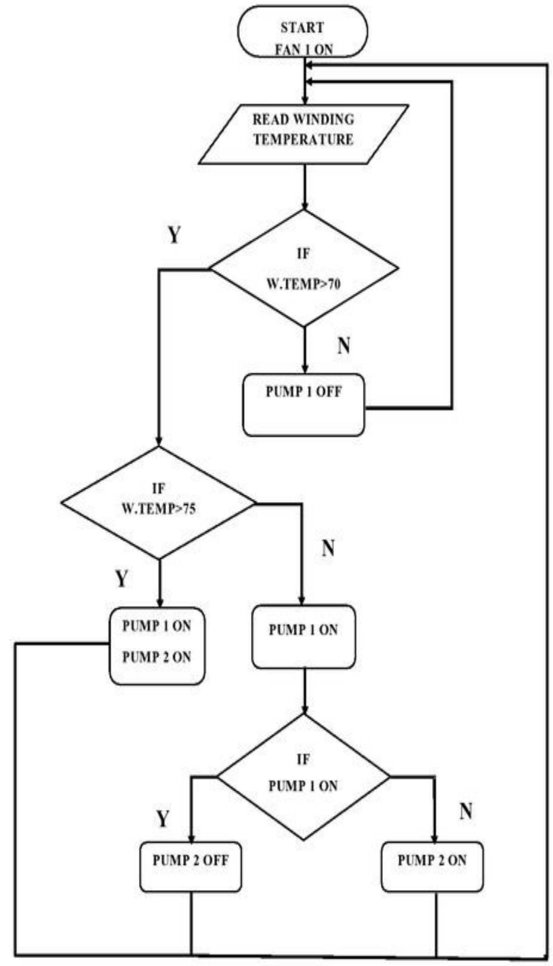


Figure 4: Flowchart 2: Temperature ranges for pump

V. ADVANCEMENT IN THE SYSTEM

The added improvisation in this system is the indication of oil level in the tank. The provisions are extended by standby or reverse fans and pumps in case of any failure in the cooling. If the oil level falls below 60,800 liters (for 250 MVA generating transformer), oil low-level indication alarm is given. Simultaneously the oil temperature is monitored to prevent the transformer and also to maintain the oil purity. If the oil temperature attains 75° C, an alarm indication is given and system trips if the temperature goes beyond 85°C.

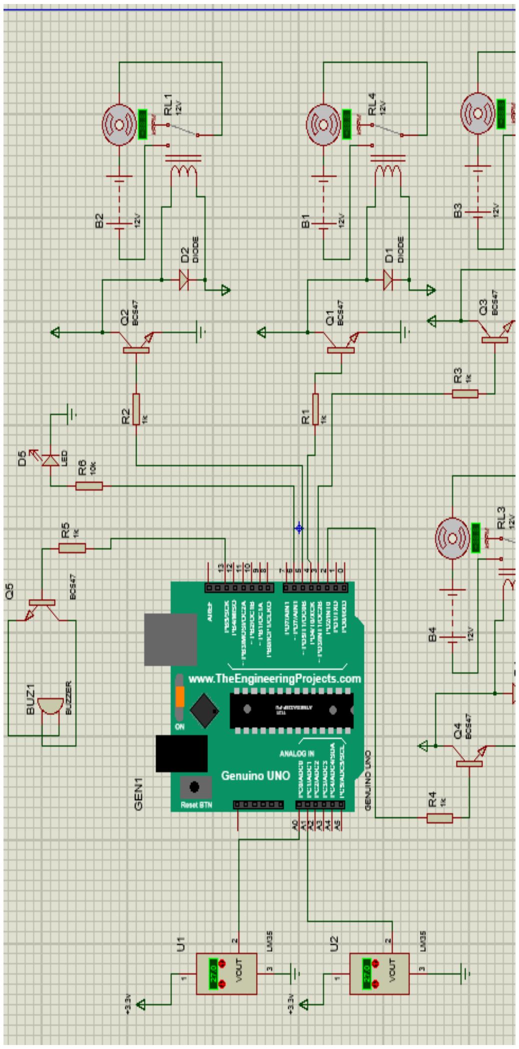


Figure 5: Circuit diagram of the proposed system

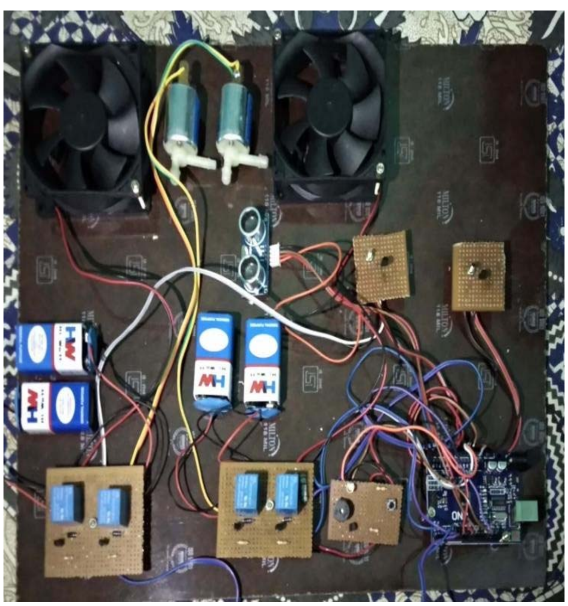
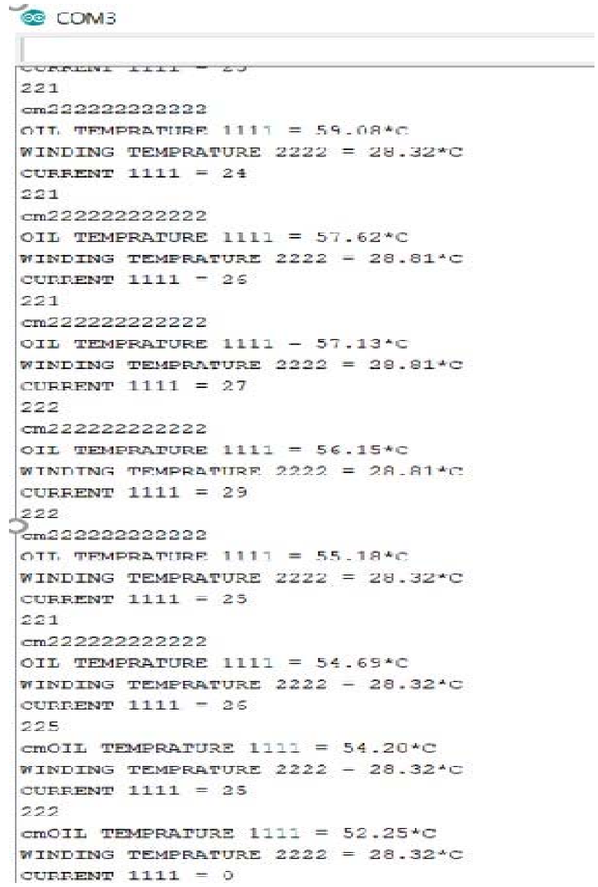


Figure 6: Image of the prototype

VI. RESULTS AND OBSERVATION



```
COM3
CURRENT 1111 = 25
221
cm222222222222
OIL TEMPRATURE 1111 = 59.08*C
WINDING TEMPRATURE 2222 = 28.32*C
CURRENT 1111 = 24
221
cm222222222222
OIL TEMPRATURE 1111 = 57.62*C
WINDING TEMPRATURE 2222 = 28.81*C
CURRENT 1111 = 26
221
cm222222222222
OIL TEMPRATURE 1111 = 57.13*C
WINDING TEMPRATURE 2222 = 28.81*C
CURRENT 1111 = 27
222
cm222222222222
OIL TEMPRATURE 1111 = 56.15*C
WINDING TEMPRATURE 2222 = 28.81*C
CURRENT 1111 = 29
222
cm222222222222
OIL TEMPRATURE 1111 = 55.18*C
WINDING TEMPRATURE 2222 = 28.32*C
CURRENT 1111 = 25
221
cm222222222222
OIL TEMPRATURE 1111 = 54.69*C
WINDING TEMPRATURE 2222 = 28.32*C
CURRENT 1111 = 26
225
cmOIL TEMPRATURE 1111 = 54.20*C
WINDING TEMPRATURE 2222 = 28.32*C
CURRENT 1111 = 25
222
cmOIL TEMPRATURE 1111 = 52.25*C
WINDING TEMPRATURE 2222 = 28.32*C
CURRENT 1111 = 0
```

We observe that when external heat is applied to the winding temperature sensor, there is an increase in temperature. As soon as the winding temperature reaches 55°C, fan 1 starts to operate and when there is a further increase in temperature of about 60°C, fan 1 and fan 2 are set into operation. Similarly, when the temperatures 65°C and 70°C are reached we observe that pump 1 and pump 2 are set into operation respectively. When the oil temperature rises upto 75°C, an alarm indication is given and the system trips off at 85°C.

. VII. CONCLUSION

In our project, we use a microcontroller that is Arduino for logic implementation, which reduces the number of external components and wiring. Thus the implementation become cost-effective and gives an ideal solution. In our project, we use a microcontroller that is Arduino for logic implementation, which reduces the number of external components and wiring. So it becomes easier to trace the circuit during fault conditions.

VIII. FUTURESCOPE

The cooling methods can be improvised in future trends which will result in a profitable increase in generation of power. More advanced microcontrollers can be used to enhance the controlling features of the system. The operating time can be improvised in future trends.

ACKNOWLEDGEMENT

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