Project on the cooling control panel of the transformer using microcontroller and power electronics device. ----------- Jigar Maheshbhai Modi

## PROBLEM SUMMARY:

- Transformer is a static device which is used to step up and step down the voltage working on the principle of electromagnetic induction.

- There are many faults occurring in this device such as
  1. Faults in winding
  2. Faults in core, etc.

- As we havegone through industrial visit we have found out number of problems.

- Problems such as faults in winding like short circuit in winding, less number of turns, height problem etc. Also they face problem in core like short circuit in core, height problem etc.

- But all such problems they were find out during testing of transformer but not able to find out before testing.

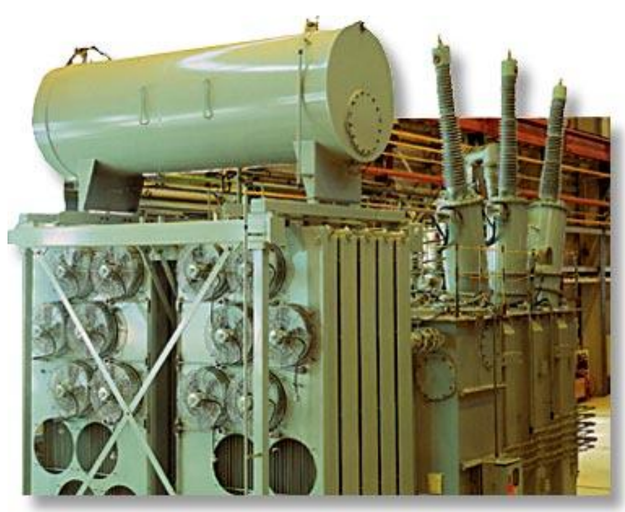
- One more problem is there in cooling control panel of transformer in which they are using timers, contactors, relays, etc. to start the fans for cooling purpose of winding if the winding temperature is increased by certain limit.

 Use of timers, contactors, relays in cooling control panel makes it very complicated and expensive.

 Thus, we have taken the problem of cooling controlpanel and trying to solve this problem by making cooling control panel compact and inexpensive.

Need of the cooling control panel:

➤ 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 than to the transformer oil. The transformer oil is provided in the transformer for the cooling and better insulation purpose. The heat than transferred to the transformer oil. The heat sinks are provided for the transformer walls cooling.



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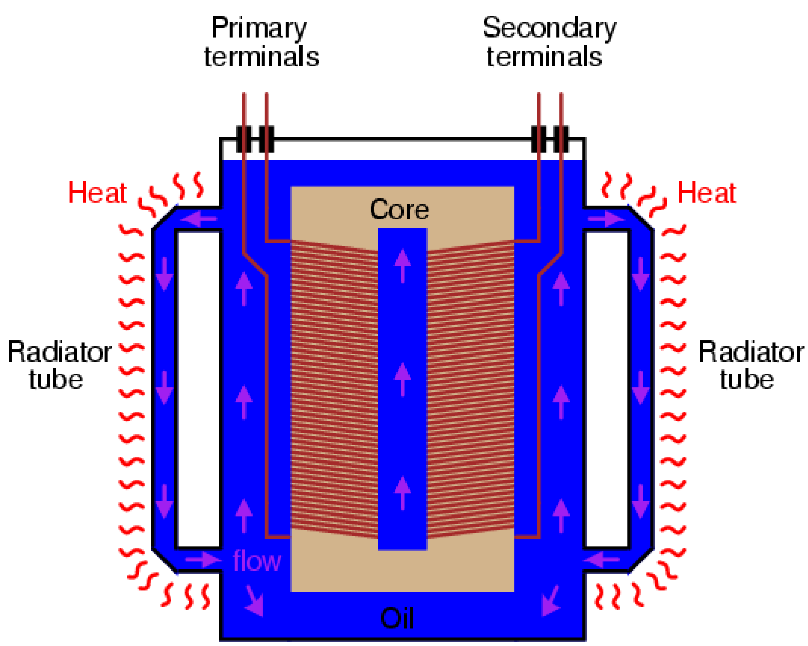
Cooling Fans for transformer tank cooling

Figure:6

The heat is transferred to the heat sinks and there, there are fans provided outside the transformer to cool the transformer walls. The numbers of fans are connected in the parallel connection outside the transformer. Here in the above diagram the heating of the transformer is shown.




Transformer Heating

Figure:7

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There are number of tubes from which the heat is transferred in the natural air. But for the high ratting transformers the heating is much more due to the more losses in the core. So, there are fans provided for the better cooling of the transformer. The transformer oil is the primary insulating material. In the normal transformers there is the Winding Temperature Indicator (WTI) and the Oil Temperature Indicator (OTI) is used for the temperature measurement of the transformer. There is cooling control panel in the transformer for the control of the temperature of the core in the transformer.

The cooling control panel contains WTI, OTI, MCBs, Thermocouple, Timers, Contactors, Alarm and etc. The MCBs are used for the protection of the cooling control panel. The WTI and OTI are used for the temperature measurement. They are situated in the transformer tank. The timers are used for the operation of the switches within the time.

The thermocouple is used to measure the temperature and gives the analog signals as the output. OTI and WTI are instruments which are important, if not the most important, protection and control devices for transformers.

They are used to control the transformer cooling equipment, such as fans and pumps if available, they provide alarm signals and they typically also trip the transformer – or in other words take the transformer out of operation, should the temperature become too high. The transformer size from which the usage of this kind of equipment starts can vary but in many cases the power rating of the transformer is above 2 MVA, but depending on requirements and application, it may start at even lower ratings.

The instruments are of direct reading mechanical dial type and should be self powered, meaning no power source is required for the indication and function of the devices. They basically consist of three parts assembled together to one complete instrument; a case where the indication dial and switches are housed together with the mechanics that drive the indication and switch operation, a sensing bulb which is the actual temperature measuring part and then a capillary that connects the sensing bulb to the case.

The complete sealed measuring system can be filled with a gas (pressurized system) or more popular with a liquid (non-pressurized system) to obtain the temperature from the transformer. The instruments are compensated for ambient temperature changes, necessary because of the large ambient temperature operating range.

→ WTI:

WTI measures the temperature of the winding. In this there is one rod that is put nearer to the winding and that rod senses the temperature.WTI only measures the temperature of the winding there is one another instrument used to measure the temperature is called OTI. The below is the diagram of the WTI.

Winding Temperature Indicator

Figure:8

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The dial indicating the actual temperature should be large and clearly visible, also from a distance. Commonly a white dial with black letters and black pointer is used, but also the opposite can be found. A large dial deflection eases the readability over the entire measuring range which often is 0 to +150 °C, but also other ranges are used. Normally every 2 °C are marked on the dial, but occasionally some instruments instead show every 5 °C. Different accuracy tolerances are offered – normally from 2% to 1% depending on requirements. Important is that the indicator is equipped with a resettable red coloured maximum indication pointer to show the maximum temperature since the last reset. This provides valuable information on the possible degradation of the insulation material inside the transformer.

Lately the number of instruments equipped with remote reading capability has increased. This is due to the fact that many transformers are in remote places or hard to get access to, to check the actual temperatures. The remote reading, typically a 4-20 mA signal, but also other signals are available, can be connected to a SCADA system (supervisory control and data acquisition system), a computer or network, or to a remote indicator of analogue or digital type – or to a combination of these functions – which certainly facilitates the access to the actual temperatures.

The switches are of microswitch type, available with different ratings depending on application and voltage that are being used with the switch. Typically the usage for AC switching up to 15 A, for Voltage of 110 or 220 VDC and for mA signals require different types of microswitch contact material – meaning different types of switches – also combinations of different switch types in the same instrument are becoming more popular.

The switches should be of SPDT (single pole, double throw) type so that either the normally open or the normally closed function (or both) can be chosen. However, sometimes DPTD (double pole, double throw) switches are required, when exactly the same switching point

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for two contacts is necessary. This can for instance be used for simultaneous trip and alarm functions. More information on switches and settings for instruments can be found under the respective part on OTI and on WTI.

The temperature sensing bulb is mounted on the top of the transformer for IEC style transformers and typically on the side for ANSI style transformers. To avoid moisture getting into the transformer oil, should the replacement or upgrade of the instrument become necessary, the bulb is close to always put into a pocket (also sometimes referred to as a well).

The pocket can be welded or connected by a thread to the transformer tank – and offers a threaded connection for the sensing bulb. The size and thread dimensions can vary and is depending on standards and common practice in different countries. Basically there are two versions of the pockets – dry-type and oil-filled pockets. On IEC transformers the most commonly used version is the oil-filled pocket, which often comes with thread size G3/4", G1" or M22 x 1,5 mm, but also other sizes can be found. The dry-type pockets are found on ANSI style transformers and on IEC transformers from certain manufacturers, and offers a very tight fit between the bulb and the pocket to allow for a good heat transfer. The oil-filled pockets are larger in size and therefore need the oil inside for the heat transfer.

Oil-filled pockets should never be completely full once the bulb is put into the pocket, since the oil in the pocket expands with increased temperature and thus need space for the expansion. A rule transformer - either a mineral or a silicon type.

The temperature sensing bulb is connected to the case by the capillary. The required lengths range from 1 m up to well above 20 m, although the mostly used versions are 4 to 8 m. The capillary is a metal tube that allows the liquid (or gas) to be transmitted between the

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bulb and case. The inner diameter is very small, around 0,5 mm is common – while the outer diameter as well as choice of material vary between different brands.

The recommendation to avoid damages if persons should step on the capillary or bend it too sharply is to use Cupper-Nickel alloy material and an outer diameter of 3 mm. In addition the capillary should be housed inside a protective hose or armour for increased safety. These armours could be a stainless steel protection or a PVC hose where the former provides superior mechanical protection.

The instruments are typically used outdoor, although in certain cases there may be requirements on installations inside cubicles. They are normally found in eye-height mounted directly to the transformer tank wall.

Since transformers vibrate with a frequency (the same as the network frequency, 50 Hz or in certain countries 60 Hz) or a multiple thereof, the use of anti-vibration mountings is highly recommended. This is to avoid wear of parts and prolong the lifetime of the instrument.

Stainless steel mountings are preferred based on vibration reduction and lifetime versus rubber parts which wear because of sun and environmental influences and thus have shorter expected life time.

Transformers are used all over the world, so the instruments should be designed for climates ranging from arctic to tropical including a large ambient temperature operating range.

Transformers and their accessories, including the temperature indicators, are expected to have a long life time – requirements of min 20 years expected life time are common. Therefore the choices of materials, paint and overall quality of the instruments are very important to consider.

Furthermore the OTI:s and WTI:s are required to be maintenance free as well as free from additional re-calibrations throughout the life time of the devices which put high demands on these gauges.

→ OTI = Oil Temperature Indicator

Liquid immersed distribution transformers, power transformers and reactors are using oil as insulating media and for cooling. The temperature of the oil increases by the load of the transformer. In fact it is mainly the resistance in the transformer windings that increases the temperature of the winding and then subsequently the oil – the higher the current through the winding is the higher the temperature will get.

The winding is cooled by the oil – which is then heated up. Since the life time of the transformer is depending on the deterioration of the insulating material around the windings, typically some kind of paper material – and this material is aged quicker at higher temperatures, it is important to check and control the oil temperature. This is done by the use of Oil Temperature Indicators, usually called OTI:s.

They are designed to measure the oil temperature and provide a clear temperature indication as well as providing the option of starting/stopping cooling equipment, giving alarm and trip signals. All transformers larger than 2 MVA are equipped with minimum one OTI – in certain countries the use of two separate OTI:s on each transformer is common, especially on larger size transformers where the oil temperature might differ slightly depending on the location of the pocket and temperature sensing bulb. Apart from the general description above, some important features to consider are listed below.

In certain countries or areas it is advisable to use a low temperature lock out for some functions on the transformer. One specific function is the operation of the OLTC (On-Load Tap-Changer). Since the oil inside the transformer at low temperatures, say from -20 °C and lower, is hardly in liquid state, meaning more similar to butter than to oil to use an everyday comparison, the changing of taps which is a fully mechanical movement of the OLTC, should be blocked to avoid severe damages.

This is easily done by using an OTI having one of the switches operating at a low temperature setting. This might require special dial ranges, like from -40 °C or perhaps even lower and perhaps an additional switch, where both are options available from most suppliers.

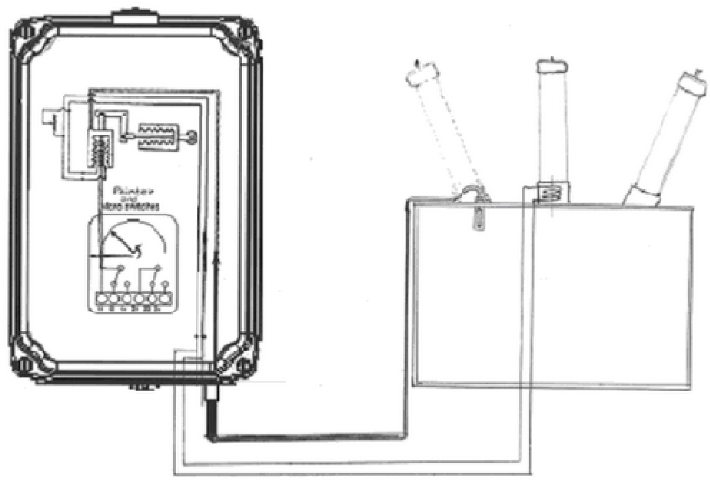
Important features to consider when choosing OTI are the functions for operating the cooling equipment of the transformer. One advantage is if the switches have large hysteresis (switching differential), so that one switch can be used for both turning on as well as turning off the cooler (fan or pump).

This is important so that the cooling equipment is not constantly turned on or off (hunting) because of a too small hysteresis of just a few degree C, which will lead to a strong wear of the equipment. A recommendation often seen is a differential of min 10 °C for this purpose. This size of hysteresis eliminates the need of timers or an additional switch for turning off the cooling. Another feature is the contact rating, where high allowed contact ratings can eliminate the need of interposing relays or contactors.

Here it is important to verify if the operating voltage is AC or DC since these might require different types of microswitches. Not only a high contact rating is important but also the expected life time for the stated rating. Since the switches for the cooling equipment will operate frequently during peak seasons – and that the expected life time of the transformer is in the range of min 20 years, the number of operations can add up to 100.000 operations and sometimes higher.


Oil Temperature Indicator

Figure:9



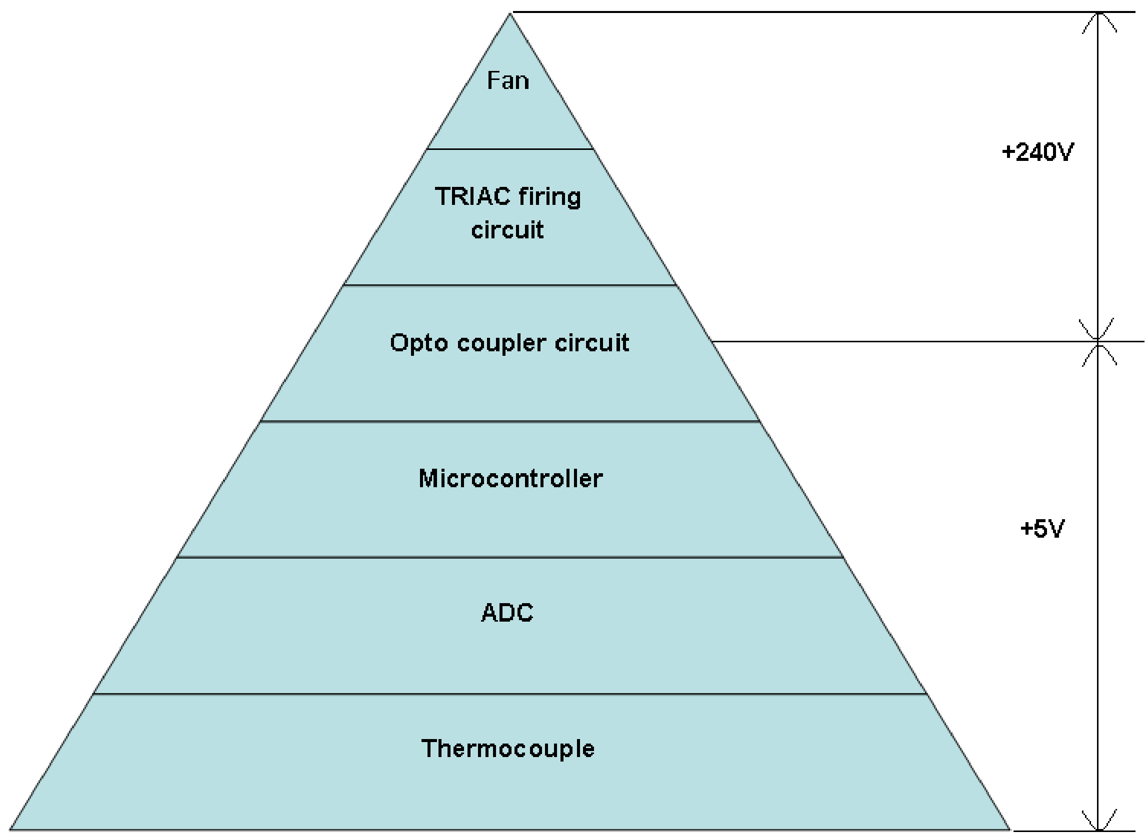
Connection of OTI in the above diagram

Figure:10

## CHAPTER: 6

- Main Circuit:

In this circuit there are six components are used. The six components are Thermocouple, ADC, Microcontroller, Amplifier Circuit, Opto coupler circuit and fans. The simple structure is shown in the figure below.




Simple circuit structure diagram

Figure:11

The very first thermocouple is used to sense the temperature. The thermocouple gives the analog output so there is the requirement of the analog to digital converter (ADC).

The ADC is connected with thermocouple. The ADC is connected with the microcontroller to control the digital output signals. The controller is externally supplied with the +5V power supply.

The microcontroller is than connected with the opto-coupler circuit for the switching purpose. The LCD display is connected with the microcontroller to display the measured temperature.

The LCD screen continuously displays the temperature of the transformer winding and oil. The temperature is sensed by the thermocouple is very accurate measurement. The opto-coupler circuit is supplied with the normal +240V power supply.

The microcontroller is connected with digital to analog converter (DAC) to convert the digital output into analog output. The operational amplifier is used to increase the measured output voltage because the output voltage of the DAC is too much low.

The Operational Amplifier is connected with the opto-coupler circuit. The opto-coupler circuit is connected with the fans. Opto-coupler circuit works as the switching circuit. It works on the principle that when the output voltage changes up to certain level it gives the supply voltage as +240V to the fans and fans are ON in series one by one for certain range. The main structure is shown below.

In the structure the circuit is working in series from the bottom of the pyramid to the top of the pyramid. The Pyramid is shown for the easy way of the circuit description. The LCD screen is also connected to the controller.