Application of computer and modern automation system for protection and optimum use of High voltage power transformer

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Abstract: **High voltage power transformer is widely used in all over the world as generation of Electrical Power in either voltage level. In power-transformer lots of equipment working together like cooling fan, Buchholz relay, breather, bushing, differential relay and so on. So It is necessary to find out problems occur in it and to eradicate them as early as possible so the high cost of High voltage power transformer does not get damage and optimum use. Here we should focus how to diminish and operate them in smarter way. In this paper an attempt has been made to elaborate the use of computer and modern automation system for protection and optimum use of High voltage power transformer, its advantages and cost effectiveness. Programmable logic controllers (PLC) can be used for control & automation of High voltage power transformer. The main reason for this is cost effectiveness and optimum use. Various functions and controls can be achieved by programming the PLC. They can be used for full plant automation including governing of auto-operation includes cooling fan, control, oil level control, automatic start/stop of pump, transformer oil leakage control, replacement of Buchholz relay by pressure sensor control, start/stop of auxiliary systems, and protection requirement etc Functions other than control like continuous monitoring, data recording, instrumentation and protections can also be performed. For remote operation, communication with PLC can be performed. For continuous monitoring purpose, a personal computer can be interfaced with PLC and continuous data can be recorded regularly.**

Keywords: High voltage power transformer, Programmable logic controllers

1. INTRODUCTION

In any power plant where High voltage power transformer is placed. Beside that one control room is there. Which control the transformer operation manually and some portion by using relay and circuit breaker. They operate sub controlling equipment as their own control not as the transformer requirement with respect to time and variation. The control, protection and Monitoring of High voltage power transformer in power plant through automatic control is the most important thing.

For this purpose we will use PLC (Programmable Logic Controller). The PLC was invented in response to the needs of the American automotive manufacturing industry. In 1968 GM Hydramatic (the automatic transmission division of General Motors) issued a request for proposal for an electronic replacement for hard-wired relay systems. It uses a programmable memory to store instruction and specific function that include on/off control, timing, counting, sequencing, arithmetic, and data handling. PLC is the one of the most powerful tools used for control in High voltage power transformer. Control and monitoring of the High voltage power transformer equipment can be easily done by PLC.

2. Need of Automatic control of High voltage power transformer in plant

1) Lots of high rated cooling fan working as cooling purpose equipments is very costly in High voltage power transformer plant. So automatic control will provide all time protection in relatively chipper cost by using low power and proper management.
2) In power plants over loading condition can judge and protect the High voltage power transformer from overheating.
3) Replace the high cost differential relay by using PLC logic circuit.
4) All information about transformer can reach in the control room and can make a proper strategy for management.
5) Reduce the manpower requirement.
6) Provide more effective and very smooth operation.
7) The operating cost will decrease very significantly.
8) It gives more reliability.

3. Automatic control of High voltage power transformer

Based on the foregoing analysis, the control of the High voltage power transformer equipment can be done by various way. It consists lots of device shown in fig.1.

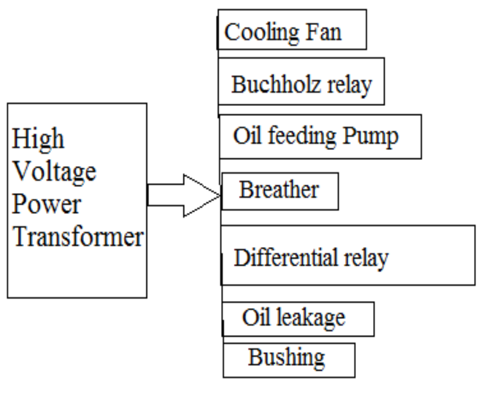

Fig.1 All necessary protection part of transformer

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3.1 The cooling fan control by using PLC (Programmable Logic Controller)

The transformers are having two winding one primary and another secondary .the windings wound on the low-reluctance magnetic material, usually iron. 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 [9] and better insulation purpose. The heat sinks are provided for the transformer walls cooling [1]. The heat is transferred to the heat sinks and there are numbers of fans are connected in the parallel provided outside the transformer to cool [2] the transformer walls. If we are able operate them in according to need because temperature in day time, night time, in winter session, or in summer session are different so, then we can save the power and can increase the life of the system [3].
Here we will use different type of heat sensor like Thermistor, Thermocouple, Optical sensors or Infra Red based any sensor can use. And output of this sensor is used as input of PLC port and according to input it will operate the no. of fan.

Fig. 2 A high voltage power transformer with 15 cooling fan.

Here we use the Programmable Logic Controller with temp. Sensor for control these fan.

Recommended Maximum Temperature settings are;

A. Oil Temperature Indicator: 85°C for Alarm switch; 95°C for Trip switch
B. Winding Temperature Indicator: 105°C for Alarm switch; 115°C for Trip switch

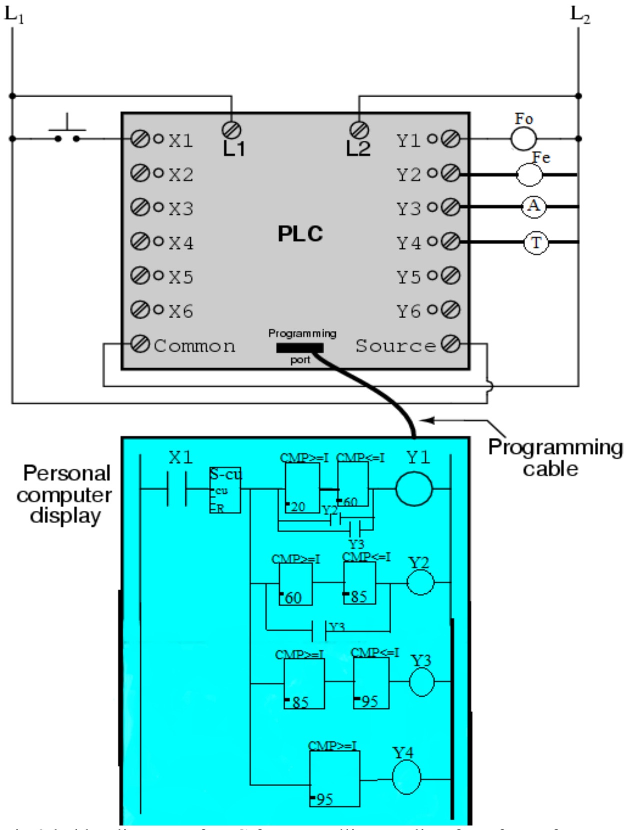

Fig.3 ladder diagram of PLC for controlling cooling fan of transformer

Input X1 is the output of temperature sensor, S-cu is the continues counter which will feed counted data in to the comparator if temp. 20°C< X1< 60°C then Y1 will energies which will operate Fan (Fo) F1,F3,F5,......F15.
If temp. 60°C<X1<85°C then Y2 will energies which will operate all fan (Fo, & Fe).
If temp. 85°C<X1<95°C then Y3 will energies which will operate all fan and produce a alarm (A).
If temperature is more than 95°C then Y4 will energies, which will produce a trip signal and provide a safety from overheating condition.

3.2 The Buchholz relay replacement and control by using PLC (programmable logic controller)

The Buchholz relay is connected in the pipe work between the transformer tank and conservator [4]. The Buchholz relay is completely filled with oil. There are two switches presents inside in for alarm and trip [5].

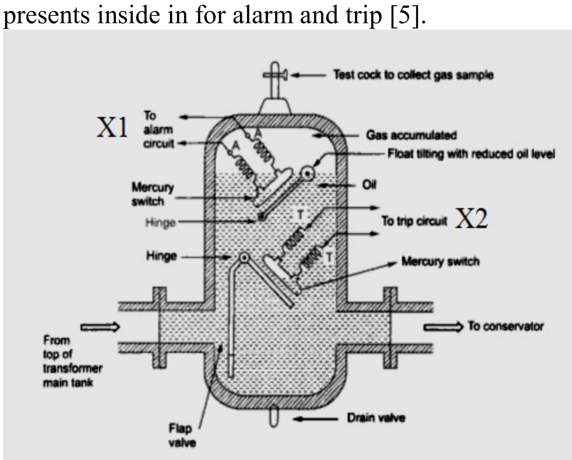

Fig.4 Buchholz relay with alarm(X1) and trip(X2)

When fault occur in the interior of the transformer tank, gas bubbles are produced which accumulate in the Buchholz relay on the way to the conservator then the oil level in the relay enclosure drops which in turn lowers the upper bucket(X1). This causes the mercury switch to operate an alarm signal(Y1). The lower bucket does not change its position, because when the gas reaches the upper inside wall of the pipe it can escape into the conservator. Hence, minor fault in the transformer tank will not trigger the lower switching and will not trip the transformer. In case the liquid continues to drop due to loss of oil, the lower bucket also goes down. In consequence, the lower switching(X2) system operates if the level of oil goes below the bottom level of the pipe connected to the relay. Alternately in the event the liquid flow exceeds a specific value the lower bucket is forced down, thus triggering the lower switching(X2) system to operate. Under specified fault condition, gas produced rapidly due heat of oil transformer these gas full the relay container so the oil level become reduced and relay coil trip (Y2) according to level of oil in relay coil.

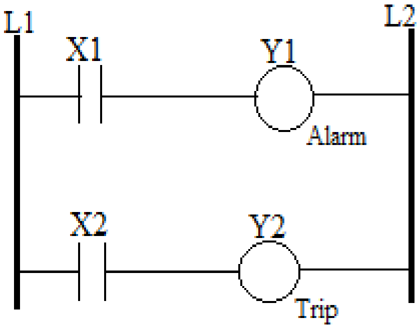

Fig.5 ladder diagram of PLC with Buchholz relay

When X1will get input then Y1 will energies and it will produce alarm, and if X2 will get input then Y2 will energies and it will produce trip signal.

3.3 The Breather control by using PLC (programmable logic controller)

As transformer load is increases the insulating oil of the transformer gets heated up, expands into the conservator tank present at the top of the power transformer and subsequently pushes the dry air out of the conservator tank through the silica gel breather. This is known as breathing out. In case of breathing in the oil cools down, air from the atmosphere is drawn in to the transformer through silica gel breathers [8].

The purpose of these silica gel breathers is to absorb the moisture in the air sucked in by the transformer during the breathing process. Silica gel breathers [11] provide an economic and efficient means of controlling the level of moisture entering the conservator tank during the breathing process. When it absorb a huge amount of moisture or saturated its colour changes from blue to pink.

Fig. 6 silica gel in breather after oxidation(Pink) and before oxidation (Blue)

In many of the cases we noticed that the breather does not replace after it become saturated. Which is dangers for transformer oil. In normal condition weight of silica gel is very light but after oxidation, its weight is heavy, for sensing this situation use force sensor like Piezoelectric Sensor. And output(X1) of this sensor will input(X1) of PLC circuit which will energise the coil (Y1) which will produce the alarm (in fig.8) or indicate for changing the silica gel.

3.4 The Oil feeding pump control *by using PLC (programmable logic controller)*

The pump unit is connected by pipes on the on-load tap-changer head. The head is equipped with flange connections for oil feed (suction pipe) and oil return. The pump [6] unit contains the feed pump, the pump motor and the filter cartridge. The flange connections for the oil [9] feed/return pipes are installed on the upper and lower cover of the tank. This is as shown in the fig.7.

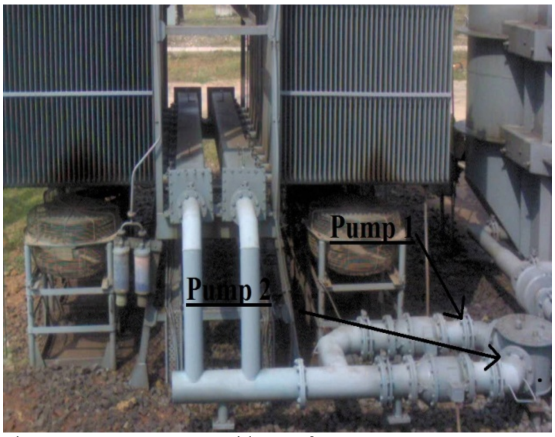

Fig.7 Pump arrangement with transformer

Cooling [13] control is highly dependable on the transformer and the cooling design. The cold oil should feed to the transformer by the help of pump. For pumped units, oil flow sensors are used for sensing the flow (X3) and heat sensor are used for sensing heat of the transformer oil (X2). This X2, X3 are the input of ladder diagram and outputs are Y2 (pump 1), Y3 (Pump 2), Y4 (alarm).

Fig.8 are showing Ladder diagram of PLC for controlling Pump section. When temp. Is more than 20°C then coil Y2 will energies and it will run the Pump 1 And flow sensor (X3) will sense the flow if coil Y2 is energies and input through X3 is zero then Coil Y3 will energies which will start the pump2 and give a Syrian which will show the pump1 is not work properly.

input	input	output	output	output
X2	X3	Y2	Y3	Y4
0	0	0	0	0
1	1	1	0	0
1	0	1	1	1
1	1	1	1	1

Table. 1 logic table for PLC for controlling Pump section

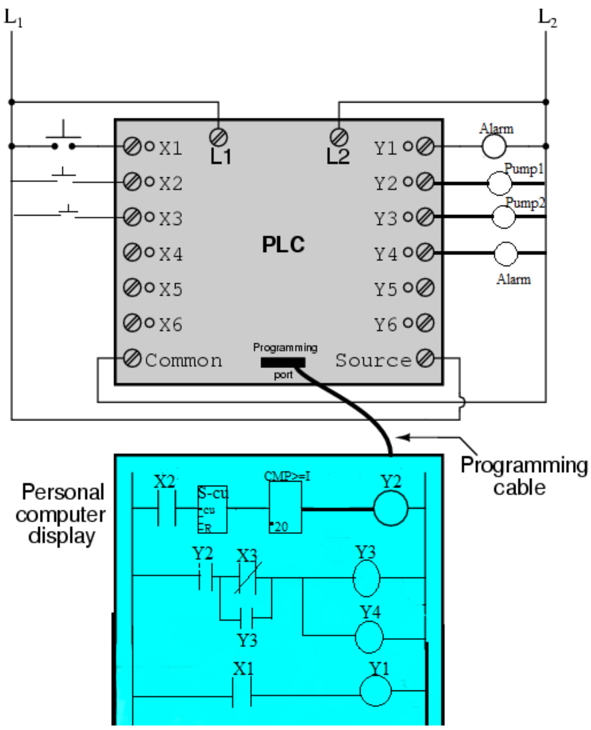

Fig.8 Ladder diagram of PLC for controlling Pump section and breather.

3.5 The Oil leakage control *by using PLC (programmable logic controller)*

Inside of a transformer mainly OIL PLANT CAPACITY of 60KL/Day , in case of TOBS storage capacity-1000KL, In process Oil storage capacity-125KL(20KL filters-3nos,10KL filters-6nos and 5KL filter-1no) So it mainly provides following facilities:

1. To provide dielectric strength of the transformer insulation system.
2. To provide efficient cooling.
3. To protect the transformer core and coil assembly from chemical attack.
4. To prevent the buildup of sludge in the transformer.

So it is vital to detect any fault occur due to the Oil leakage [7] It is basically done by measuring the pressure inside the transformer with the help of various high prise machine like HY-PT -1 Pump Test Bench(Oil test leak flow 10-760 ml./min).

The basic principle for finding the oil leakage in it, to measure the pressure inside in it.

This can be done by the help of pressure sensor and the data(X1) generated by pressure sensor can be control by PLC Controller logic. Logic diagram is shown in the fig.9. Since transformer oil is very flammable oil so when sensor sense and X1 give input then controller will trip the operation and alarm will produce a Syrian.

3.6 The bushing control by using PLC (programmable logic controller)

Transformer Bushings [9] are made to for electrical circuit terminals for taking out winding ends (leads) through the openings provided on the top cover or wall of the of transformer tank and connecting to the incoming and outgoing line.

The bushing acts as an insulator to prevent a short circuit. In large distribution transformers or in, High voltage power transformer. The voltages used are so high that it the wires cannot be allowed to come too close to each other, or too close to the metal casing of the transformer. If they do get too close, then the voltage can actually jump through the air (electrical breakdown), and create a short circuit. The bushings [14] are made longer than they need to be because things like rain, and sharp points on a transformer terminal can make it easier for the voltage to jump through the air. EHV Transformer Bushing failure is a potential problem and it can also lead to Transformer damage. The latter problem is more serious in terms of loss of revenue, time, and transformer repair expenses. These Bushings [13] are maintenance free and fitted with pressure monitoring devices to monitor bushing internal faults. The pressure monitoring device of the Bushing was able to sense the failure [12] at the initial stage.

And from the output of this device (X2) will decide the next step, for example if current is less then 5A then only through alarm (Y3) informed to the control room. And if this is more than 5A then direct trip (Y4) the operation. This all thing can do through LPC. Which is shown in fig. 9

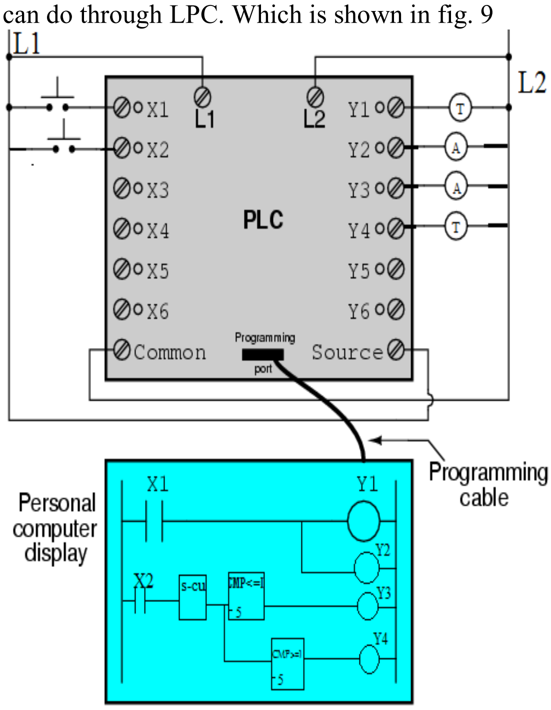

Fig.9 Ladder diagram of PLC for controlling Oil leakage and bushing

3.7 The differential relay control by using PLC (programmable logic controller)

According to current differential relay [10] protection scheme the primary winding connect through a CT and secondary winding also connected to a CT. The ratios of both the CT windings are different to get same output current from each CT windings. Now these output feed to a comparator, the comparator output decide the condition of transformer.

If both the output is same then comparator output is zero and no action taking place or transformer working properly. But if there is any fault occurs due in oil heating, overloading, gas forming etc in transformer then the two outputs of CT windings will be different so the comparator gives some output. On the basis of these output action taking place. Weather transformer should be isolated from system or it is on under the limiting condition.

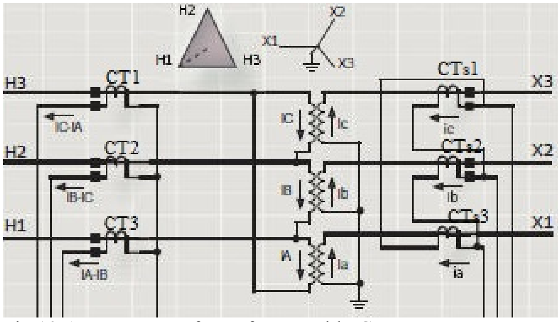

Fig.10 Arrangement of transformer with CTs

Three CTs are in primary side (CT1, CT2, CT3) and three CTs are in secondary side (CTs1,CTs2, CTs3) and similarly output of this CTs are Ia, Ib, Ic, ia, ib, and ic. In normal condition in each phage primary and secondary current are same. Here comparison, taking decision and giving command for trip in faulty situation is done by PLC.

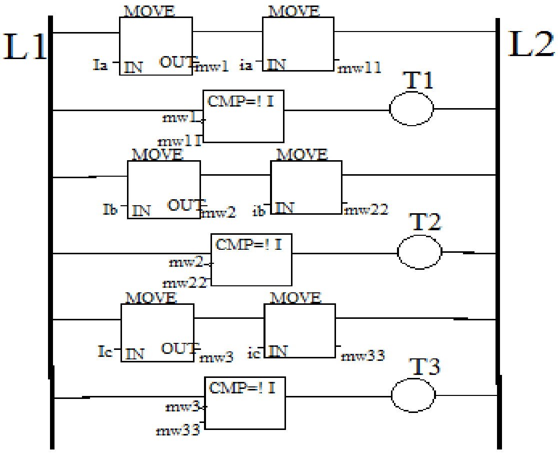

Fig.11 Ladder diagram for *differential relay* control *by using PLC*

4. Advantage of automatic control in power transformer

a. Reduce the wastes of power in protection system.
b. Fast detection and protection under any internal fault condition.
c. All condition and situation operate from a single computer.
d. Reduce the operating and protecting cost of the transformer.
e. We can do optimum use of the transformer and other related device.
f. Increase the life of the transformer.
g. Improvement in the performance and Safe operation of the transformer.

5. Conclusion

In this paper we are using computer with PLC based logic for controlling whole component which are involved in a protection of transformer and also use the component only at the moment of need, so it reduce the wastage of power and unnecessary operation. Generally the cost of relays, timer, counter, comparator etc are higher and in our system or in a plant we are using so many these type of component for a proper operation. In this situation by using PLC we can replaced all these hardware system to a single computer. Another benefit is that PLC sense the situation and gives information before the dangerous situation to the control room. So that we can take a necessary step for that situation. These strategy provide a best platform where protect and use optimum of high voltage power transformer.

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