

Transformer Fault Detection and Protection System

Kowshik Sen Gupta
Department Of Electrical & Electronic Engineering, International Islamic University Chittagong (Iiuc)
85/A, Chatteshwari Road, Chawk Bazar, Chittagong-4203, Bangladesh

Abstract:
In this project all designs are constructed based on two major systems. One is RTD (Resistance Temperature Detector) and another is PLC (Programmable Logic Controller). Resistance Temperature Detector (RTD) is temperature sensors that provide the variable resistance value as its temperature changes. It gives the output of the value of resistance corresponding to the transformer winding temperature to PLC. A programmable Logic Controller (PLC) is a digitally operating system designed for use in an industrial environment, which uses a programmable memory for its internal operation of user-oriented instructions and for implementing specific function such as logic, sequencing, timing, counting and arithmetic. PLC has a program on the microprocessor then microprocessor processing the program on base of RTD output and PLC gives command to start the cooling fan to decrease the temperature. If temperature is increasing over the safety limit than PLC disconnects the incoming power of the transformer for its safety.
Keyword: PLC, RTD, Transformer winding, Cooling fan.

1.Introduction:

A transformer is a static machine used for transforming power from one circuit to another without changing frequency. Transformers are an important and expensive component of the power system. Due to the long lead time for repair of and replacement of transformers, a main objective of transformer protection is limiting the damage to a faulted transformer. Some protection purpose, such as over excitation protection and temperature-based protection may aid this goal by identifying operating conditions that may cause transformer failure. There are many protection is used for Transformer safety. The transformer winding temperature is another quantity that should be used for protection of transformers. Protection based on winding temperature can potentially prevent short circuits and catastrophic transformer failure, as excessive winding temperature cause degradation and eventual failure of the winding insulation. The ambient heat, transformer loading, and transformer design determine the winding heat. Temperature based protection function alarm or trip when certain temperature conditions are met.

2.Programmable logic controller (PLC):

Programmable logic controller was first designed by the engineers of general motors' corporation in 1968 to eliminate costly assembly-line relay logic circuit, during model changeover. Presently, more than 50 companies are manufacturing PLCs. The automotive industries started the development of the PLC primarily because of massive rewiring that has to be done every time when a model change occurred.PLC modules are much easier to change than the relay panels. This advantage was reflected in the cost of installing and operating the PLC instead of traditional relay system.A programmable Logic Controller is a digitally operating system designed for use in an industrial environment, which uses a programmable memory for its internal operation of user-oriented instructions and for implementing specific function such as Logic, sequencing, timing, counting and arithmetic. PLC controls digital or analog inputs and outputs in the various types of machines or processes. Only handle digital signals. For modern PLC's can handle various types of analog signals. It can handle Voltage, Current, thermocouple (TC), resistance temperature detector (RTD), pulse, high speed count signal etc. It can perform all types of PID control for single loop and complex control loop. It can also perform the servo-control.

3.Power Transformer Protection

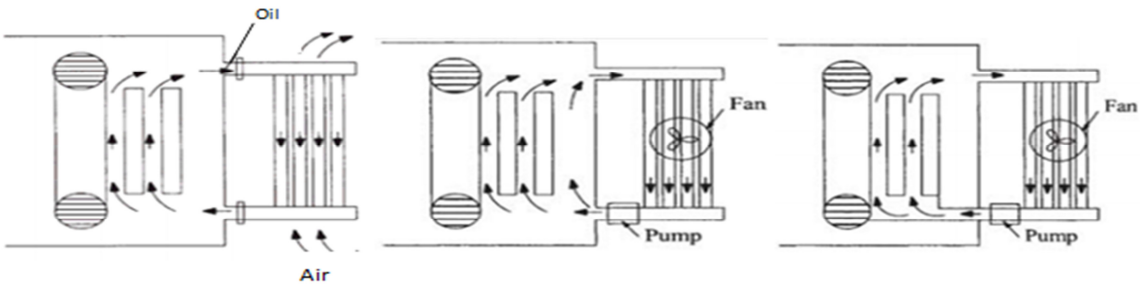
A power transformer is a very valuable and vital link in a power transmission system. High Reliability of the transformer is therefore essential to avoid disturbances in transmission of power. A high quality transformer properly designed and supplied with suitable protective relays and monitors is very reliable. Less than one fault in 100 transformer years can be expected. The operation and maintenance of a transformer can be a contributory cause of a fault. If a transformer is operated at too high temperature, too high voltage, or exposed to an excessive

number of high current external faults etc., the insulation can weaken to the point of breakdown. A breakdown of the insulation results in short circuits or ground faults, frequently causing severe damage to the windings and the transformer core. Furthermore, a high gas pressure may develop, damaging the transformer tank
.

Transformer cooling types:

The transformer cooling types are given below:

1. Natural Cooling
2. Forced Air Cooling
3. Oil Natural Air Natural (ONAN)
4. Oil Natural Forced Water (ONFW)
5. Oil Natural Air Forced (ONAF)



6. Oil Forced Air Forced (OFAF)

(a) (b) (c)

Fig1: Transformer cooling types (a) ONAN, (b) OFAF, (c) ODAF

4.Resistance temperature detector (RTD)

Resistance Temperature Detectors (RTDs) are temperature sensors that contain a resistor that changes resistance value as its temperature changes. They have been used for several years to determine temperature in laboratory and industrial processes, and have urbanized a reputation for accurateness, repeatability, and constancy. Each type of temperature sensor has a exacting set of conditions for which it is best suited. RTDs
Offer several advantages:

1. A wide temperature range (approximately-200 to 850°C)
2. Good accuracy (better than thermocouples)
3. Good interchangeability
4. Long-term stability

With a temperature range up to 850°C, RTDs can be used in all but the highest-temperature industrial processes. When made by metals such as platinum, they are very stable and are not affected by corrosion or oxidation. Other materials such as nickel, copper, and nickel-iron alloy have also been used for RTDs. However, these materials are not usually used since they have lower temperature capabilities and are not as stable or repeatable as platinum.

5.Universal transmitter

A Universal Transmitter is the device that controls anything to its attached serial devices. It Converts the bytes it receives from the along parallel circuits into a single serial bit stream for outbound transmission. The important things of a Universal Transmitter is

- Universal.
- User-friendly.

- Reliable.

Technical characteristics:

• When 4116 is used in combination with the 4501 display / programming front, all operational parameters can be customized to suit any application. As the 4116 is intended with electronic hardware switches, it is not necessary to open the module for setting of DIP switches.

• A green / red facade LED indicates normal operation and malfunction. A yellow LED is ON for each active output relay.

• Continuous check of very important stored data for safety reasons.

• 4-port 2.3 kVAC galvanic isolation.

Mounting:

Mounted vertically or horizontally on a DIN bar. As the modules can be mounted without any distance between neighboring units, up to 42 modules can be mounted per meter.

6.Working principle:

When press the start button the command goes to PLC input. Then PLC Check program logic and give output to the relay (R1). Therefore transformer get input power on primary side and a light connect in secondary side will be ON. So the transformer take current from the source and winding will heat up. RTD set up with winding by the Transformer Manufactured Company. RTD all time sense temperature of winding and send resistance value to PLC. Microprocessors of PLC check program logic, which program already in PLC memory. If the winding temperature is rise to 50^{o}C then PLC will give command to start the cooling fan and cooling fan will stop when winding temperature reach 45^{o}C. If the temperature exceeds 50^{o}C after starting cooling fan and winding temperature reach 60^{o}C then PLC will give command to stop the relay (R1). Therefore Transformer input power will OFF for the transformer winding safety. The Emergency stop switch is used for shutdown the system.

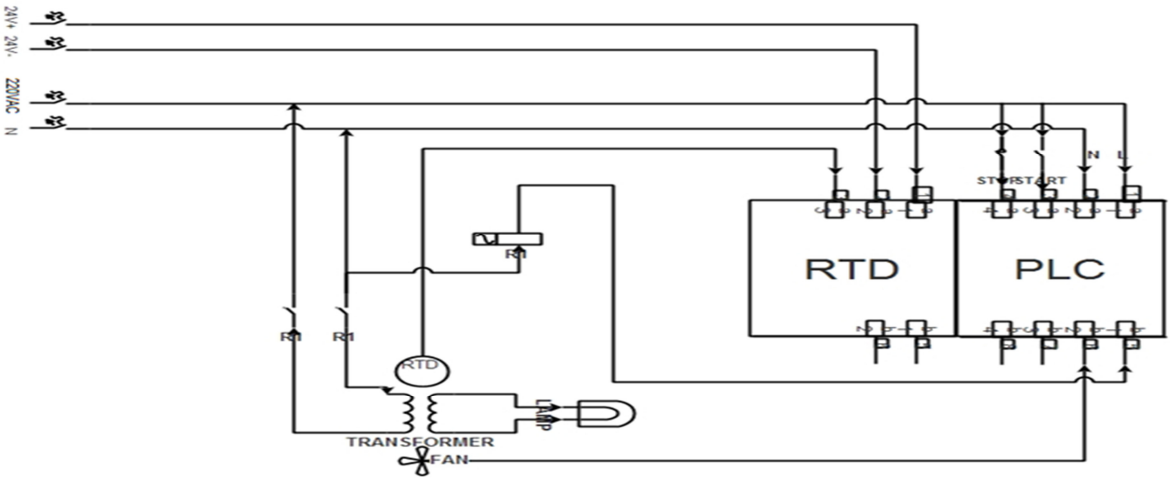


Fig2: Circuit Diagram Of Transformer Fault Detection And Protection System

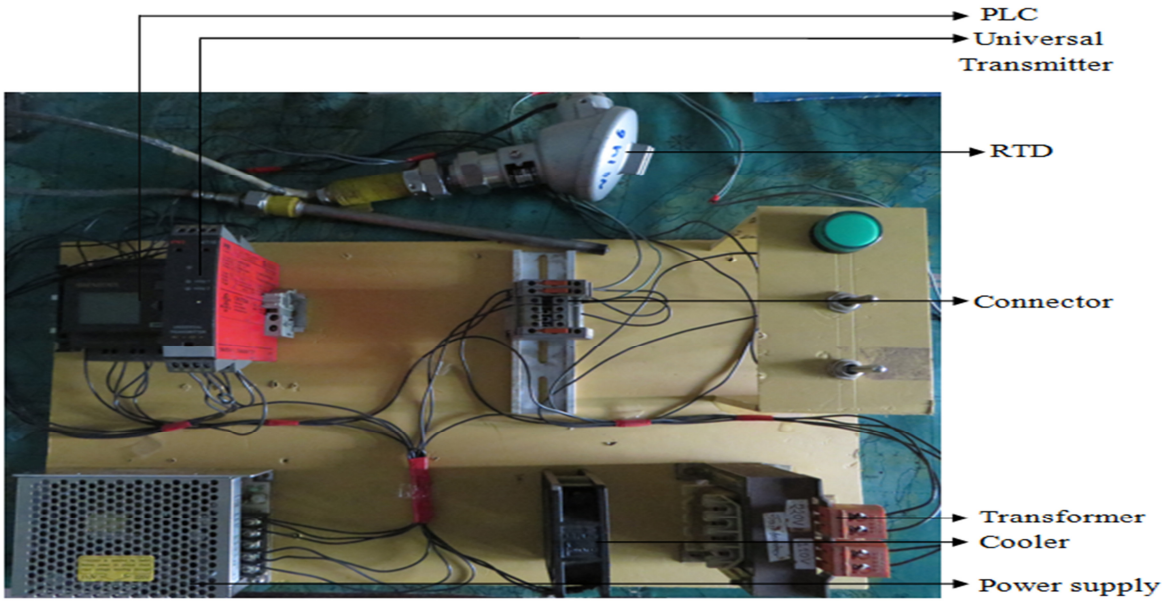


Fig3: Transformer Fault Detection And Protection System.

7.Conclusion

In this project we have presented a design of a system based on PLC that is used to monitor the temperature of a transformer and protect the transformer. The proposed PLC system which has been designed to monitor the transformer's essential parameters continuously monitors the parameters throughout its operation. The RTD recognizes any increase or decrease in the level of temperature values. When the temperature increases gradually then the cooling fan start and tries to control the temperature. But if the temperature goes too high which cause damage the transformer cores then the relay will disconnect the transformers from the transmission line and protect the transformers. In the same time the cooling fan
will run and cool the transformer. When the temperature again comes in the safety level the relay will again connect the transformer with the transmission line. Most of the substation can use this protection system for transformer for the sensitive and reliable operation. This process of cooling can be used for the other devices like circuit breaker, bus bar unit, power factor improvement panel etc. inside any substation using a single PLC unit. In future the transformer temperature can be monitored and the Protection can be operated from office by networking.

Acknowledgement:
Authors would like to thank our supervisor honorable sir **Engr. Aasim Ullah**, Lecturer, Department of Electrical & Electronic Engineering, IIUC and all the faculty member and technical stuff of dept. of EEE, International Islamic University Chittagong.

References:

[1] Bryan L.A. and Bryan E.A, "Programmable Logic Controller, Theory and Implementation," second edition, United States of America, 1997.
[2] John W.Webb and Ronald A. Reis, "Programmable Logic Controller, Principles and application", Fifth edition, Lebanon, India, United States of America, 2002.
[3] Armando Guzman, Stan Zocholl, Gabriel Benmouyal, et al. A Current-Based Solution for Transformer Differential Protection - Part I: Problem Statement. IEEE Trans. Power Delivery, 2001,16(4): 485-491 .
[4] Armando Guzman,Stan Zocholl,Hector J.Altuve. A Current-Based Solution for Transformer Differential Protection - Part II: Relay Description and Evaluation. IEEE Trans. Power Delivery, 2002, 17(4): 886-893.
[5] Phadke A G., Trop J S. A New Computer based Flux Restrained Current Differential Relay for Power Transfonner Protection. IEEE Trans.s on Power Apparatus and System, 1983, 102 (11): 3624-3629.
[6] Yabe K, Power Differential Method for Discrimination between Fault and Magnetizing Inrush Current in Transformer [J]. IEEE Transaction on Power Delivery, Vol.12, No. 3, 1997, 7: 1109-1118.
[7] XUE Dake, JI Shengchang, LI Yanming, et al. A theoretical research on on-Line monitoring of winding defonnation of power transformer [J].High Voltage Engineering,2000, 26(3): 16-18.
[8] SEL-787 Instruction Manual, Schweitzer Engineering Laboratories, Inc. Available: http://www.selinc.com/instruction-manual.htm.
[9] C. F. Wagner and R. D. Evans, Symmetrical Components. New York and London: McGraw-Hill, 1933.
[10] J. Mraz, J. Pomeranz, and J. D. Law, "Limits of Sensitivity for Detecting Inter-turn Faults in an Energized Po wer Transformer, " proceedings of the 34th Annual Western Protective Relay Conference, Spokane, WA, October 2007.
[11] A. Guzmán, "Transformer Internal Fault Model for Protection Analysis, " MS thesis, University of Idaho, Moscow, ID, 2002.
[12] A. C. Franklin and D. P. Franklin, J & P Transformer Book, 11th ed. London: Butterworth & Co., 1988, pp. 436-438.
[13] P. Anderson, Analysis of Faulted Power Systems. New York: Wiley- IEEE, 1995, pp. 260-261.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar