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Automatic Method of Protection of Transformer Using PIC Microcontroller

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Abstract - **This paper describe the design and implementation of an "Automatic method of protecting transformer using PIC Microcontroller". The aim of this paper is to provide an alternative, effective, efficient and more reliable method of protecting fault from power transformer which may arose as a result of over voltage, overcurrent, over temperature. Generally, fault may occur in transformers due to the stated reasons. Along with above said faults system is designed to indicate Transformer oil quality. This isolation process is to ensure that the transformer is safe from any excess current levels that can make it to overheat thus get damaged. Thereafter regarding the monitoring and control, information about the operation of the parameters would be transmitted to a personal computer for general monitoring and control, which avoid the need of the lines men who had to go to the transformer to re-fix fuses.**

Index Terms - Microcontroller based Automatic method of protecting transformer. Voltage, Current, Oil Quality, Temperature monitoring of a transformer.

I. INTRODUCTION

The power transformer is one of the most significant equipment in the electric power system, and transformer protection is an essential part of the general system protection approach. Transformers are used in a wide variety of applications, from small distribution transformers serving one or more users to very large units that are an integral part of the bulk power system [1].

Protection against fault in power systems is very essential and vital for reliable performance. A power system is said to be faulty when an undesirable condition occurs in that power system, where the undesirable condition might be short circuits, over-current, overvoltage, over temperature etc.

Increase in population leads to increase in demands of electrical power. With the increase in demand of power, the existing systems may become overloaded. Overloading at the consumer end appears at the transformer terminals which can affect its efficiency and protection systems. One of the reported damage or tripping of the distribution transformer is due to thermal overload. To avoid the damaging of transformer due to overloading from consumer end, it involves the control against over-current tripping of distribution transformer. Where the advancement of technology has given the edge to use the latest trends, such as microprocessor, microcontrollers are used as one of the requirements to apply in the remote protection of the transformer.

For decades, fuse, circuit breakers and electromechanical relays were used for the protection of power systems. The traditional protective fuses and electrometrical relays present several draw backs.

Alternatively, some researches were conducted on relay which can be interfaced to microprocessors in order to eradicate the drawbacks of the traditional protective techniques [6], which led to many improvements in transformer protection in terms of lower installation and maintenance costs, better reliability, improved protection and control and faster restoration of outages.

In view of the associated problems of traditional methods of protecting transformer, a proposed solution is chosen to develop a microcontroller based transformer protection prototype because the microprocessors based relays provides greater flexibility, more adjustable characteristics, increased range of setting, high accuracy, reduced size, and lower costs, along with many ancillary functions, such as control logic, event recording, self-monitoring and checking, etc. [2].

II. SYSTEM DESIGN

The below block diagram is designed to evaluate the hardware description.

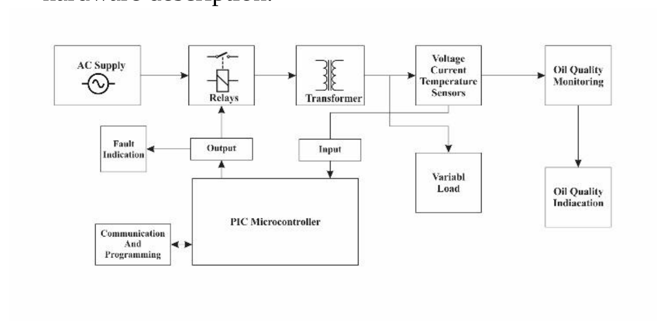

Fig.1. System Block Diagram

The above block diagram which is designed out of literature reviews conducted, numbers of components are required in developing the protection system. As shown in Fig 1, the output of the transformer (i.e. secondary side) is connected to a load which is usually electrical appliances such as bulbs, electric heater etc. The current sensor connected in series with load is used to measure the load current while to measure the voltage, it is rectified and divided using potential divider and then fed to the Analog to Digital converter of the microcontroller. Whenever there is overheating, overvoltage and over-current, the microcontroller sends a trip signal to the relay and the relay shutdowns the transformer, thereby protecting the transformers. The oil quality is continuously monitored using IR trans-receiver and it is indicated by LED. The microcontroller acts as the brain of the entire system, and the relay acts as the protective device of the system. Similarly, the system can be modified to send the transformer parameters to other devices as PC, HMI panels for monitoring and control.

A. Over-current protection circuits

An Analog ammeter cannot be used in measuring the load current as an analog signal must be fed into the ADC of the microcontroller for monitoring the load current. A current sensor is the suitable current sensing device for this setup. The current sensor used can measure up to 30Amp. The ACS712 is used for this purpose. The ACS712 is power up with 5V and gives out voltage to indicate the direction and current value.

The output of the current sensor is fed to Microcontroller ADC unit for taking the necessary action. Increase in current is detected by current sensor as load is varied from minimum to maximum. For indication purpose LED is provided at the output of the Micro-controller Chip. Figure 2 shows load sensing circuit.

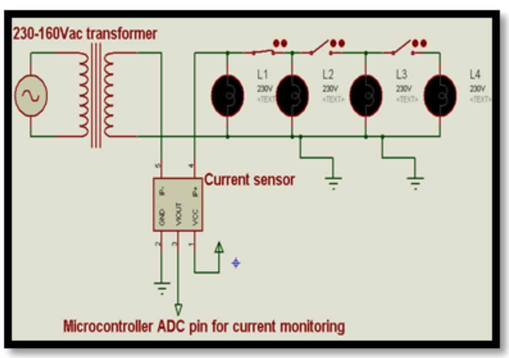

Fig.2. Load sensing circuit

B. Over and under voltage protection circuit

Rectified dc voltage output is used to measure the load voltage. This voltage is fed to the ADC via potential divider. The over voltage and under voltage protection circuit is capable of measuring and monitoring voltage from 175 to 230 voltage. In this setup, the voltage can be increased or decreased by using the autotransformer. Whenever the voltage is varied below 180Vac, the microcontroller will detect under voltage fault and whenever the voltage is varied above 220Vac, the microcontroller detects over voltage fault, consequently the microcontroller sends a trip signal to the relay, and the relays cuts the primary of the transformer from the AC mains, thereby protecting the transformer.

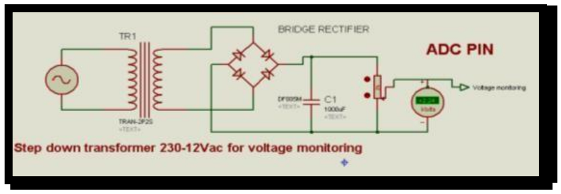

Fig. 3. Over and under voltage sensing circuit.

Figure 3, shows a step down transformer of 230-12Vac that was used and rectified to a pure dc using the capacitor and then adjusted to voltage within 5Vdc using the potential divider to fed the analogue signal into the ADC. Whenever the primary voltage of the transformer is adjusted, the secondary voltage also changes, and based on the microcontroller program, the input voltage can be monitor, displayed and the transformer can be protected from any fault.

C. Temperature Sensing

Not only over load current or overvoltage may not result in damage to the transformer but also the temperature of the windings and transformer oil must remain within specified limits. The ratings of transformer are based on a 24-hour average ambient temperature of 30°C (86°F). Due to over voltage and over current, temperature of oil increases which causes failure of insulation of transformer winding. When the temperature of transformer increases to upper limit of temperature rating, the over temperature fault will occur. This fault can detect by temperature sensor. LM35 is used as temperature sensor. LM35 contains 3 pins viz. Vcc, Output, GND. It converts temperature value to linear voltage value. Output of LM35 is fed to ADC of Microcontroller. If temperature of transformer is increased above 60 degree C then relay shuts down transformer supply indicating the fault on LED.

D. Oil Quality

Transformer oil primarily functions as insulator and coolant for transformer. Transformer oil quality is important in context of transformer working. Transformer it helps to preserve core and winding as these are immersed inside oil. It also prevents direct contact of atmospheric oxygen with paper insulation of windings which is susceptible to oxidation. In this setup oil quality is monitored using IR Trans-receiver. Good quality oil allows transmission of IR light through it and if oil quality is degraded then it does not allow light to transmit through it. According to the quality of oil, bicolour led indication is provided. If Quality is acceptable then Green Colour LED will glow. For bad quality of degraded oil Red colour LED will glow.

III. SYSTEM FLOWCHART

Flowchart is a diagram representation of the program algorithm. The figure below shows the system flowchart.

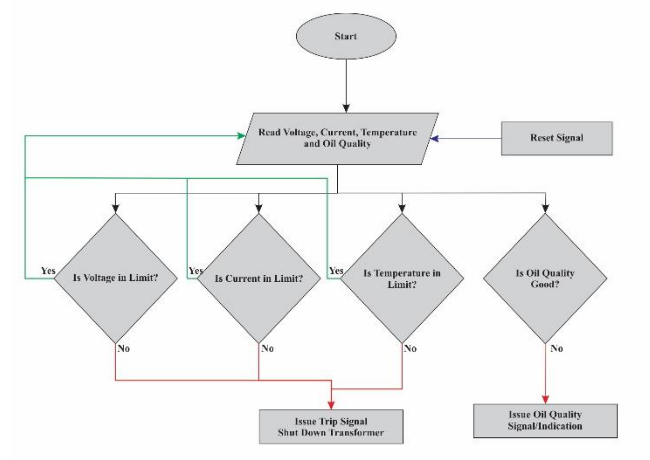

Fig. 4. System Flowchart.

The flowchart above shows the description of the system program code. Firstly, the program will initialize, read the ADC pins of the microcontroller ADC will continuously capturing the transformer parameters, as the transformer secondary current is greater than 1A, it sends a trip signal to the over-current relay, and it cuts off the load that leads to the over-current, thereby protecting the transformer from burning. Same process goes to the over voltage protection and over temperature protection, it will check whether the transformer input voltage is greater than 220 V AC, if so, it sends a trip signal to overvoltage relay, which will protect the transformer.

IV. HARDWARE AND SOFTWARE DESIGN AND IMPLEMENTATION

The circuit consists of Transformer to be protected, Voltage sensing, current sensing circuit, relay circuits, a temperature sensor and IR Trans-reciever.

The transformer to be protected in this setup is of 230 to 12 Vac step down transformer. The step down transformer voltage is been rectified and filtered to a pure dc which goes to the microcontroller ADC for monitoring the input voltage through voltage divider assembly. For the purpose of current sensing, a current sensor is used for that purpose. The current sensed by sensor increases as the number of load connected across transformer increases and this value is given to the microcontroller ADC for monitoring purpose.

While monitoring the parameters, whenever a fault occurs which might be high voltage or over current or temperature, the microcontroller sends a trip signal to the relay and thereby protecting the transformer from burning.

The system was developed with all the features of a microcontroller for transformer protection. The loads are connected to the transformer secondary, and a current sensor is connected in series with load for real time current monitoring. Based on the real time current monitored values, the microcontroller takes decision over the relay whether to cut off or not. The PIC18 microcontroller board contains all the sub circuits on-board including the high voltage sensing circuit, current sensing circuit, LED's for indication, temperature sensor, oil quality monitoring unit and relays for protection purpose.

V. RESULTS AND DISCUSSION

In order to verify the performance of the proposed microcontroller based transformer protection system, a hardware prototype was implemented with PIC18 microcontroller and crystal oscillator. During the test, an autotransformer was used for varying the input voltage of the transformer in order to create the over voltage fault. Bulbs were used as loads to implement the over current fault. Voltage and current sensing circuits were designed for sensing the transformer voltage and current. LED's are used for differentiating faulty condition and normal condition.

INPUT ⬇ / OUTPUT ➡	**LED 4**	**LED 3**	**LED 2**	**LED 5**	**LED 8**
OVER CURRENT	**ON**	OFF	OFF	OFF	OFF
OVER VOLTAGE	OFF	**ON**	OFF	OFF	OFF
UNDER VOLTAGE	OFF	OFF	**ON**	OFF	OFF

TEMPERATURE	OFF	OFF	OFF	**ON**	OFF
OIL QUALITY	OFF	OFF	OFF	OFF	**ON**

The above table shows the result setup for different fault condition.

VI. CONCLUSION AND FUTURE RECOMMENDATION

A. Conclusion

Protection of power transformers is vital task in context of power system operation. With the use of microcontrollers, protection of transformers is greatly achieved with reliability and accuracy. The system implements effective and efficient protection than the traditional methods which are currently in use. The benefits of this system over the traditional methods are that it has fast response, better isolation and accurate detection of the fault. This system overcomes the other drawbacks in the existing systems such as maintenance and response time.

At the end of the work, a complete hardware and software can be successfully implemented as prototype. The transformer voltage, current, temperature and oil quality were monitored, as soon as a fault occurs; the protective relays are triggered OFF thereby protecting the transformer from damage.

With the help of this system, the maintenance staff of the Electricity Power authority department can have a continuous vigilance over the transformer through a personal computer and rectify the problem from the computer without the need of lines men. The goal of the research was achieved successfully. The research shows that the system is fully automated with no manual interface required.

B. Future Recommendations

For future works, some recommendations have been listed in order to improve the performance.

- Use Programmable Logic Controller (PLC) instead of Microcontroller.
  PLC is an industrial computer capable of implementing different logic conditions. Above algorithm can easily implemented on PLC. Advantages of this algorithm on PLC are robustness, easy programming and easy accessibility.
- Use of GSM modem for wireless communication

Using GSM module, the data of the transformer such as current, temperature, voltage, temperature and oil quality can be sent wirelessly to monitoring authority and maintenance of the transformers can be carried out, also due to the GSM module it is able to rectify the fault from remote location.

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