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AUTOMATIC METHOD OF PROTECTING TRANSFORMER USING PIC MICROCONTROLLER AS AN ALTERNATIVE TO THE FUSE PROTECTION TECHNIQUE

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Abstract- This paper describe the design and implementation of an "Automatic method of protecting transformer as an alternative to the fuse protection technique". 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 overload, high temperature or a high input voltage. Generally, fault may occur in transformers due to the stated reasons. To safeguard the damage of the transformer with the aid and help of microcontroller we monitor and control the entire circuitry. 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. Lastly, a working system was demonstrated to authenticate the design and possible improvements were also presented.

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

I. INTRODUCTION

Protection against fault in power systems (PS) 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 etc.

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].

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.

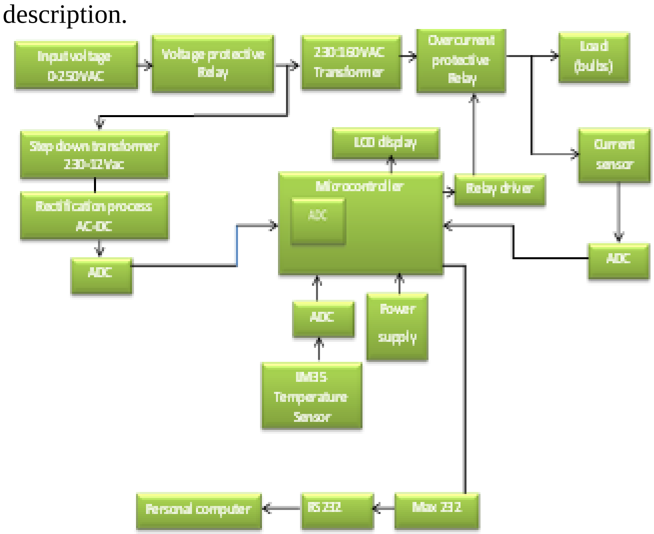

Fig.1. System design block diagram

Based on the various reviews conducted on transformer protection and the above block diagram which was conceived out of those 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 a step down voltage transformer is used to measure the voltage. The step down voltage transformer will pass through a rectification process then fed to the Analogue 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 overvoltage relay shutdowns the transformer, while the over-current relay cuts off the faulty load of the transformer, thereby protecting the transformers. The microcontroller acts as the brain of the entire system, and the relay acts as the protective device of the system. The LCD display is used to display the situation (normal and abnormal condition).
Similarly, the system has the ability to send the transformer parameters to the personal computer for monitoring and control.

A. Over-current protection circuits

Based on the research and practical implementation, an ammeter cannot be used in measuring the load current reason been that an analogue signal most be fed into the ADC of the microcontroller for monitoring the load current. A current sensor was found to be the suitable current sensing device for this research. The current sensor used can measure up to 50A. The BB-ACS756 comes with a set of Dean-T connector and a 3 ways right angle pin header. The ACS756 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 Micro-controller ADC unit for taking the necessary action. The current flowing through the CT primary can be measured. The digital display is provided at the output of the Micro-controller Chip. Figure 2 shows load sensing circuit.

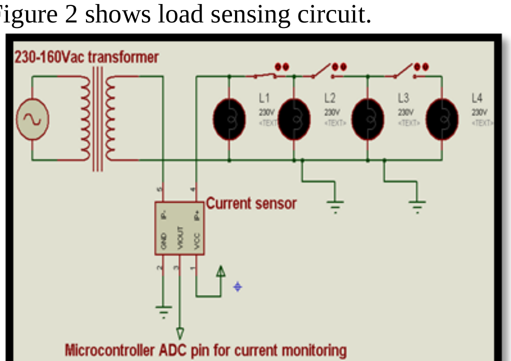

Fig.2. Load sensing circuit

B. Over and under voltage protection circuit

The 230Vac:12Vac step down voltage transformer is used to measure the load voltage. The voltage transformer will pass through rectification process before fed to the ADC. The over voltage and under voltage protection circuit is capable of measuring and monitoring voltage from 200 to 250 voltage. In this research, the voltage can be increased or decreased by using the autotransformer and the output of the voltage monitoring circuit is fed to ADC converter, whenever the voltage is varied to 200Vac, the microcontroller will detect under voltage fault and whenever the voltage is varied to 250Vac, 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.

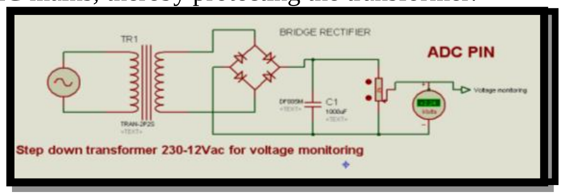

Fig. 3. Over and under voltage sensing circuit.

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 potentiometer to fed the analogue signal into the ADC without burning the ADC converter. 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.

III. SYSTEM FLOWCHART

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

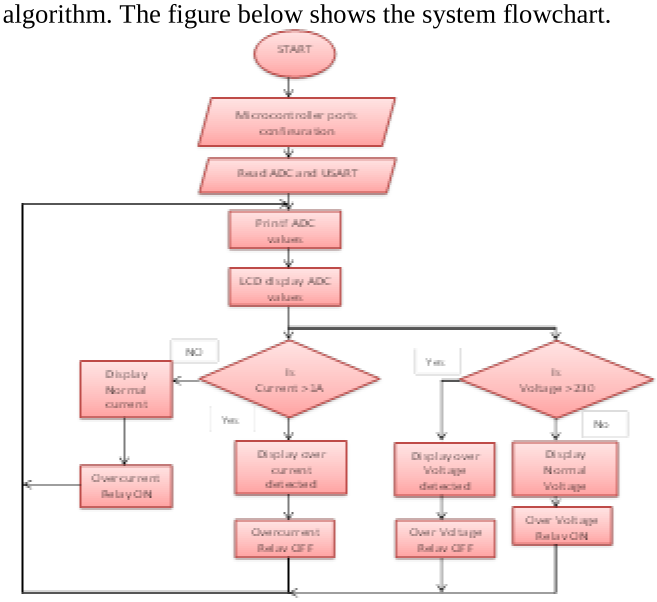

Fig. 4. system Flowchart.

The flowchart above shows the description of the system program code. Firstly, the program will initialize, read the ADC and the USART pins, thereafter sends the transformer parameters which are fed to the ADC to the personal computer system using the *printf* command, then to the LCD display. 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, it will check whether the transformer input voltage is greater than 230Vac, if so, it sends a trip signal to overvoltage relay, which will protect the transformer.

IV. HARDWARE AND SOFTWARE DESIGN AND IMPLEMENTATION

A. Complete schematic diagram

The circuit consists of PIC16F877A microcontroller; step down transformer circuit for voltage sensing, current sensing circuit, relay circuits, a temperature sensor, RS232 and the masx232 circuit.

The step down transformer used is a 230 to 12 Vac transformer and is used for the purpose of sensing the input voltage to the main transformer with a voltage rating of 230 to 160Vac. The step down transformer is been rectified and filtered to a pure dc which goes directly to the microcontroller ADC for monitoring the input voltage. For the purpose of current sensing, a current transformer was used for that purpose. It went through rectification and filtering process then directly connected to the microcontroller ADC for monitoring the load current.

The microcontrollers send the monitored parameters to LCD display and also transmit them to a personal computer. The transmission to personal computer was made possible by interfacing the microcontroller with the computer using MAX232 through RS232 serial communication. RS232 (recommended standard 232) supports both synchronous and asynchronous transmission and its user data is send as a time series of bits.

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

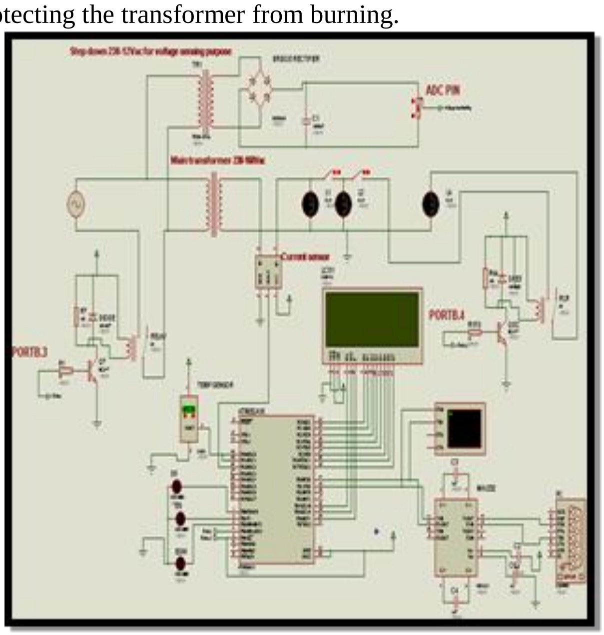

Fig. 5. Complete schematic

4.2 Visual basic 6.0 with Proteus ISIS 7 professional results

The outputs obtained from the microcontroller and transmitted to the PC via VB GUI interface are given below. Therefore, using the virtual serial port Emulator, the output was simulated perfectly. This gives us a clear idea of the hardware implementation.

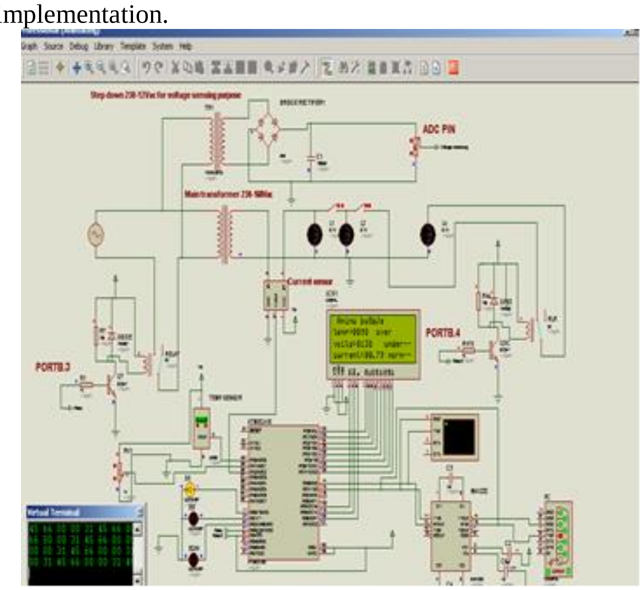

Fig. 6. Monitoring and transmitting the transformer parameters using microcontroller with proteus software

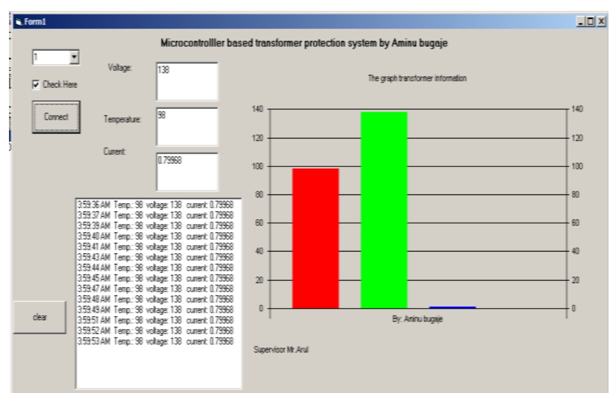

Fig. 7 Receiving and monitoring transformer parameters via PC using the VB GUI interface

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 step transformer connected to the input voltage is used for high voltage monitoring, based on the monitored voltage values; the microcontroller takes decision over the relay. The PIC16F877A microcontroller board contains all the sub circuits on-board including the high voltage sensing circuit, the liquid crystal display (LCD) for monitored values display, LED's for indication, temperature sensor, relays for protection purposes and finally the MAX 232 and RS232 for transmitting the transformer parameters to PC.

V. RESULTS AND DISCUSSION

In order to verify the performance of the proposed microcontroller based transformer protection system, a hardware prototype was implemented with PIC16F877A microcontroller and a 16MHz 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 create the over current fault. Voltage and current sensing circuits were designed for sensing the transformer voltage and current.

A. Transformer current analysis

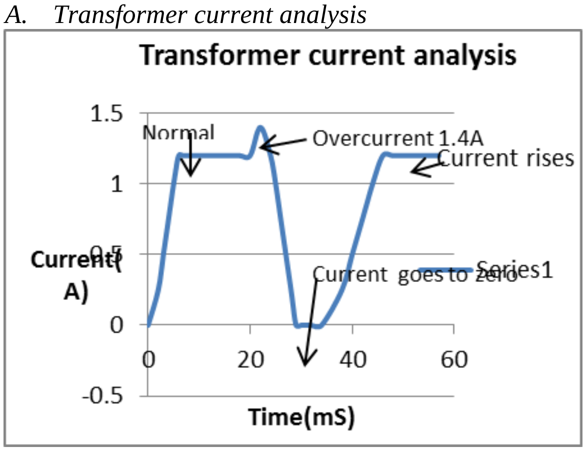

Fig. 8 Transformer current analyses

As shown in figure 8, when there's no over-current detected by the microcontroller through the current sensor, the microcontroller energizes the over-current relay ON, if loads are added to the secondary side of the transformer, the secondary current rises. Therefore the load is proportional to the secondary current. If the load connected does not exceed the rated current of the transformer which 1.2A, the relay continues to be on. But when the load current exceeds the transformer rated current, the microcontroller sends a trip signal to the over-current relay and the relay goes OFF., thereby protecting the transformer from burning due to overloading. When the over current is rectified, the relay goes ON and continues to allow the flow of electric current through the load.

B. Transformer voltage analysis

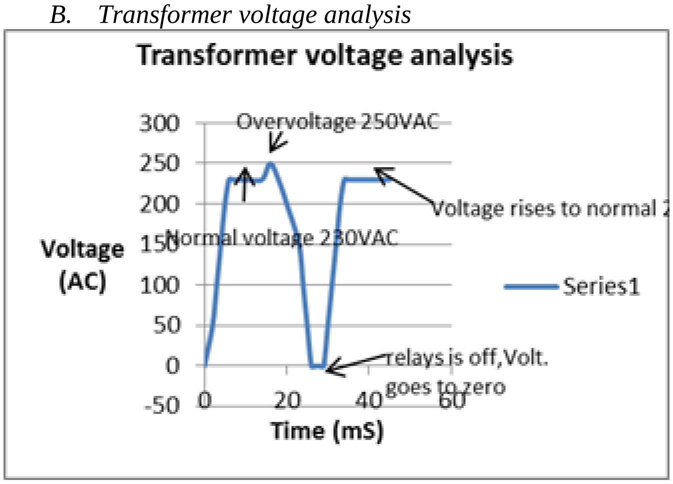

Fig. 9 Transformer voltage analyses

As in figure 9, when there's no overvoltage detected by the microcontroller through the voltage sensing circuit, the microcontroller energize the overvoltage relay on which allows the flow of electric current and voltage through the transformer primary. When the input AC voltage is varied through the autotransformer above the rated voltage of the transformer which is 230VAC, the microcontroller detects an overvoltage condition through the voltage sensing circuit, therefore it sends a trip signal the overvoltage relay, and the relay cuts OFF the primary of the transformer from the input AC voltage thereby saving the transformer from damaging as a result of overvoltage, when the microcontroller detects normal voltage, it sends back a switch ON signal to relay thereby allowing the flow of electric current and voltage through transformer primary.

VI. CONCLUSION AND FUTURE RECOMMENDATION

A. Conclusion

Protection of power transformers is a great challenge today. With the advent of microcontrollers, protection of transformers is greatly achieved with degree of accuracy. The system provides 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 were successfully implemented as prototype. The transformer voltage, current and temperature 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 of power semiconducting device as protective device:

A **TRIAC** which is a member of the **THYRISTOR** family can be used for protecting the transformer instead of using relays. As time goes on, relay might encounter mechanical problem which will lead to a poor protection. However, by using a **TRIAC**, which is a power semiconducting device, the protection will be more reliable, effective and efficient. The **TRIAC** will lead to a long life and less maintenance due to absence of moving parts. The **TRIAC** are small in size, less weight results in less floor space and therefore lower installation cost. The **TRAIC** has fast dynamic response as compared to the electromechanical relays.

- Use of GSM modem for wireless communication

Using GSM module, the information of the transformer such as current, temperature and voltage can be send wirelessly to the officer in charge of monitoring and maintaining of the transformers and also the GSM modem would give him the ability to rectify the fault without going nearer to the transformer.

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