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Power transformer protection by using microcontroller in embedded system

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Abstract—The main intention of this project is to design a microcontroller based system that can be used in power transformer protection. The system checks the operating parameters of the transformer i.e. current and reports the quantity that is flowing through the transformer. The system is designed such that it is able to detect currents above the normal operating level and isolate the power transformer from the distribution line. 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. It gives a solution to the need to reduce cost of maintenance and ensure that supply of electricity to consumers is not interrupted for long periods taken while repairing or replacing destroyed transformers.A current sensor ACS712x series has been used in this project as the interfacing instrument between the power transformer and the PIC16F690 microcontroller. The PIC16F690 controls all operations that the device does. A relay and a contactor have been used as the switching gears to isolate the current transformer (CT) from the power system in case a fault occurs. A monochrome LCD has been used to show system current readings and indicate cases of over-current fault. To warn an operator of a fault occurrence, LEDs and a piezoelectric buzzer have been used. All these

peripheral devices depend on the microcontroller to make them operate or otherwise. Some of the tools used in this project include MPLAB - programming software used to write the program for the microcontroller used in this project. Proteus-simulation software has also been used to test whether the design works appropriately before its implementation on hardware. Pickit3- has been used to load program into the microcontroller using MPLAB.

Keywords—Transformer protection, ACS, CT.

I. INTRODUCTION

In the design of electrical power transmission and distribution system, there are various factors that need to be considered in the quest to satisfy the needs of electricity consumers. Electrical power systems experience faults at various times due to various reasons. These faults must be foreseen and safety precautions applied to the power system. Power system protection is very essential and necessary for a dependable electrical power supply. It ensures that the system is protected from itself and that the consumer is also safe as he benefits from the electrical power supply. An electrical power system consists of various components such as generators, switches, transmission cables, transformers, capacitor banks among other components. It cannot therefore operate without an effective protective device to keep these components safe and the system stable. Faults in a power system refer to the undesired conditions that occur in the electrical power system. These conditions may include short circuit, over current, overvoltage, high temperatures among others. An increase in load leads to a lot of current drawn from the power line.Every transformer is designed to comfortably supply a given load. Cases of overload or short circuits can lead to transformer being damaged. To combat such occurrence, an elaborate system that monitors these excesses in supply parameters needs to be built. Such a device controls the flow of electrical power to the load so that the transformer

is not overworked. Over current relays and overvoltage relays have been used for a long period of time and have been electromechanically controlled. In this system, a microcontroller is used to monitor cases of electrical faults and communicate to a switch to isolate the transformer from the system.

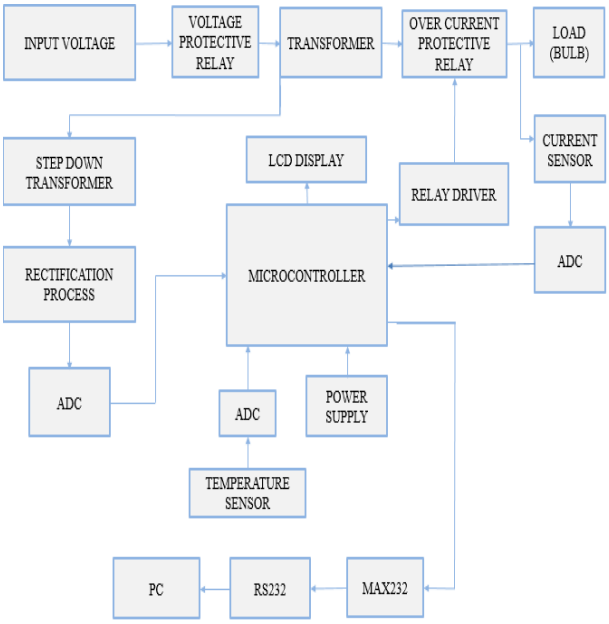
II.OBJECTIVE

Power system protection is a very important consideration in the design of an electrical power system. There is need to protect electrical power components from dangerous faults. This is warranted by the need to increase the life of the components, avoid unnecessary expenditure in frequent replacement of obsolete components and to ensure that there is a continuous supply of power to serve the needs of the ever growing economy. This project therefore seeks to design a microcontroller based system that will intelligently monitor faults and prompt a safety measure to protect the power transformer in case of power overload. The extent of the work is to build a device that detects current spikes/overload in the primary and secondary sides of a single phase transformer and isolate it from the power system.

III.PROPOSED SYSTEM

In proposed system,a microcontroller based system will intelligently monitor faults and prompt a safety measure to protect the power transformer in case of power overload. A device must be designed to cut off consumption if the system oversteps its ability thus being dangerous to users and the components. In this project, we look at the protection of power transformer from various faults that may occur and may be destructive to the component if left undetected.

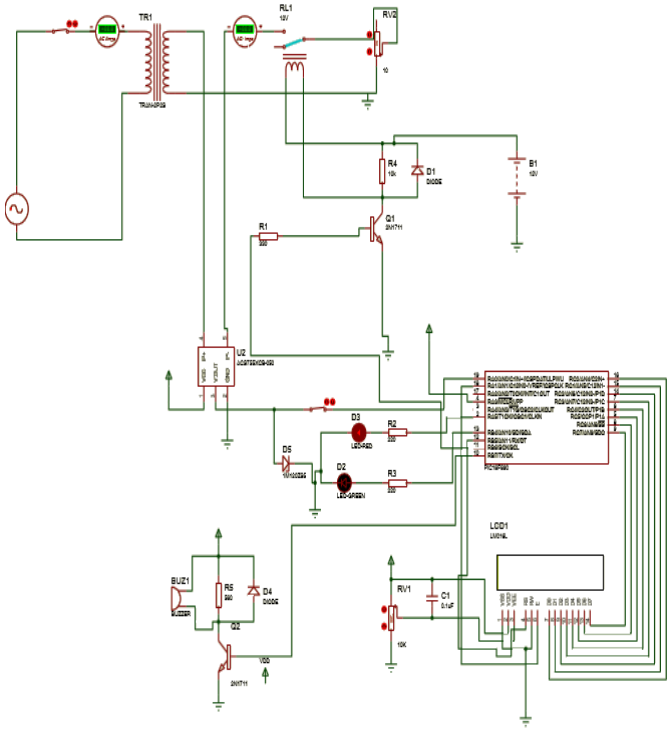
A.BLOCK DIAGRAM



B.DESCRIPTION

A PIC 16F690 Microcontroller controls all the operation that the device does. A relay have been used as a switching gear to isolate the transformer from the power system in case a fault occurs. A current sensor ACS712x has been used as the interfacing instrument between the power transformer and the PIC16F690 microcontroller. To warn an operator of a fault occurrence, LEDs and buzzer have been used. All these peripheral devices depend on microcontroller to make them operate. If the current reaches above the normal operating level, the power transformer get isolate from the distribution line. This isolation process is to ensure that the transformer is safe from any access current levels that can make it to overheat thus get damaged.

C.CIRCUIT DIAGRAM



D.CIRCUIT DESCRIPTION

The circuit consists of sensor network such as current sensor, temperature sensor and power transformer, microcontroller, LCD and relay. The current and the temperature sensor is used to sense the value of the current and the temperature level. The power transformer is used for the protecting purpose. A PIC controller compares the voltage with reference value. It drives a relay circuit as per the reference value and actual value. The LCD operates as a medium for communicating the amount of current flowing in the electric conductor at any given time. The relay acts as a switching gear.

E.HARDWARE DESCRIPTION

1. PIC16F690 MICROCONTROLLER

The PIC16F690 is a 20 pin, 8-bit microcontroller, with a modified Harvard architecture. It is manufactured by Microchip Technology. PIC stands for programmable interrupt controller.The pins of PIC16F690 can be used for multiple functions as indicated on the pin diagram. Pin 1 (VDD) is used for positive power supply while Pin 20 (VSS) is used as a ground reference. Pins on PORTA can be used for input/output purposes except pin RA3 which is solely an input pin. All PORTB and PORTC pins can be used for either input or output functions.

2. CURRENT SENSOR

This is a device that detects electric AC or DC current flowing in a conductor and gives out a corresponding signal. The detected signal can be used for various purposes like measuring the amount of current in the conductor, controlling of another device etc. The current sensor used in this project is Allegro ACS712ELCTR-30A-T. It is popularly used in diverse applications in motor control, electric vehicles and in power distribution.

3.POWER TRANSFORMER

Instrument transformers include current transformers and voltage transformers. Instrument transformers step down current and voltage from the power line to level that can be measured safely. Power transformers are transformers used in transmission networks for example in transmission substations. Their power rating is normally more than 200KVA [4]. Substation transformer is used to step down the utility service voltage.

4.RELAY

A relay is an electrically operated switch. It uses electromagnetic force to close or open contact. The relay employed in this project can be operated as normally closed or normally open. For this system, the normally closed mode was used.The relay was used to de-energize the contactor coil in case of a fault thus isolating the transformer from the system.

5.CONTACTOR

When a relay is used to switch a large amount of electrical power through its contacts, it is referred to as a contactor. Contactors basically have several contacts, and which are usually (but not always) normally-open, so that power to the load is shut off when the coil is de-energized.

6.LCD

In this project, a monochrome LCD is used because the aim of LCD usage is basically to display numerical figures and characters. LCDs consume little power thus they can be powered using battery. This project makes use of HD44780 LCD. It is a 16x2 line LCD with 8-bit wide data bus (D0-D7). It has three power pins (pins1-3), and three control pins (pins 4-5). The LCD can be operated either in 4-bit or 8-bit interface. 8bit interface makes use of all the pins while 4-bit mode uses only 4 data lines plus the other remaining pins. In this project, 8-bit mode is used.

IV.RESULTS AND DISCUSSIONS

The following results have been obtained after simulating the design on proteus. The below table shows the state of the relay, LED and buzzer as current increases. A decrease in load resistance makes current circulating in the primary side of the transformer to increase.

% Load Resistance	Sensor output (V)	Display on LCD	State of the Relay	State of the buzzer	LED Blink	LCD DISPLAY
100	0.05V	0.352A	OFF	OFF	GREEN	
90	0.06V	0.381A	OFF	OFF	GREEN	
80	0.07V	0.44A	OFF	OFF	GREEN	
70	0.08V	0.498A	OFF	OFF	GREEN	
60	0.09V	0.586A	OFF	OFF	GREEN	
50	0.12V	0.704A	OFF	OFF	GREEN	
40	0.14V	0.88A	OFF	OFF	GREEN	
30	0.19V	1.143A	OFF	OFF	GREEN	
20	0.28V	1.701A	OFF	OFF	GREEN	
10	0.51V	3.079A	OFF	OFF	GREEN	
5	0.89V	5.337A	OFF	OFF	GREEN	
2	1.70V	10.234A	OFF	OFF	GREEN	
1	2.52V	15.132A	ON	ON	RED	OVERCURRENT FAULT
0	2.52V	15.161A	ON	ON	RED	OVERCURRENT FAULT

An increase in the sensor output voltage led to a corresponding increase in the current value displayed on the LCD. Little resistance means that the load has increased thus more current is drawn from the transformer. More resistance limits current flow, signifying reduced load. So as resistance is reduced by varying the rheostat, current increases up to a point where the relay trips the circuit. This confirms that the system has been designed well and thus it is able to read and record the current as it changes, and operate the switches at optimum current levels. Finally, it is observed that when the current is varied up to the pre-set level, of 15.015A, the relay, buzzer and the red LED are triggered. The buzzer sounds an alarm notifying the operators of the fault, the relay isolates the transformer from the system, the red LED blinks to signify that the current level is too much for the transformer to supply. The LCD displays a notification that there is an OVERCURRENT FAULT.The advantage of this system over analogue over current relay is that it automatically recloses once the fault is cleared. The level of accuracy of the system is also super as compared to analogue operated over-current relay.

V.CONCLUSION

Power system protection is a very important consideration in the design of an electrical power system. There is need to protect electrical power components from dangerous faults. This system is put to use in power transformer protection can serve the purpose with greater advantages than the analogue over current relay. Its ability to automatically reclose the circuit after the fault is cleared warrants the system usability in remote areas that may be too far for an operator to reach easily and reconnect the transformer back to the supply line. The admirable fact about it is the accuracy with which it closes and recloses during either normal operation or fault occurrence. Owing to the fact that transformers are very important components of the electrical power system, their safety is paramount. Over current phenomenon can cause damage to transformers. Damage to a transformer puts interrupts electrical supply to consumers. Blackouts cause economic derailment and disorients consumers' work schedule.This system comes with a power supply that can be directly plugged to 240V source and give the appropriate operating voltage. The 240V source can be easily cultivated in a power system line. It can be used in substations or in distribution transformer.

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