OVER CURRENT PROTECTION OF 1 KVA TRANSFORMER WITH PIC MICRO CONTROLLER USING NUMERICAL RELAY

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Abstract— Transformers are the critical and expensive component of the power system. Due to the long lead time for repair and replacement of transformers, a major goal of transformer protection is limiting the damage to a faulted transformer. Numerical relay protection of transformer is an advanced method of protection. The main aim of this thesis is to protect the transformer from the over current within a short period of time. The type of protection for the transformers varies depending on the application of the transformer. When the current in a system exceeds a predetermined value, it indicates the presence of a fault. Relaying decision is based solely on the magnitude of current. The operation of the numerical relay depends upon the function of the (Peripheral Interface Controller) PIC microcontroller signal. This thesis describes the design and implementation of the PIC microcontroller based system for protecting 1KVA transformer from over current.

Index Terms— PIC microcontroller, Current Transformer, Resistive load, 1 KVA transformer, Numerical Relay.

1 INTRODUCTION

Electrical Power System protection is required for protection of both user and the system equipment itself from fault, hence electrical power system is not allowed to operate without any protection devices installed. Power System fault is defined as undesirable condition that occurs in the power system [17]. These undesirable conditions such as short circuit, current leakage, ground short, over current and over voltage. With the increasing loads, voltages and short-circuit duty in distribution system, over current protection has become more important today [18], [6]. The ability of protection system is demanded not only for economic reason but also to provide reliable service to the consumers. In a transformer Protection, the system engineer would need to a device that can monitor current, voltage, frequency and in some case over power in the system. Thus a device called Protective Relay is created to serve the purpose. The protective relay is most often relay coupled with Circuit Breaker such that it can isolate the abnormal condition in the system. In the interest of reliable and effective protection, some designers of power distribution, power controllers select relay as opposed to electro-magnetic circuit breakers as a method of circuit protection.

1.2 OVERVIEW OF OVER CURRENT PROTECTION

An Over Current Relay is a type of protective relay which operates when the load current exceeds a preset value. In a typical application the over current relay is used for over current protection, connected to a current transformer and calibrated to operate at or above a specific current level. This thesis will attempt to design and fabricate over current protection relay using PIC microcontroller [11]. The PIC micro controller will cause the circuit breaker to trip when the current from load current reaches the setting value in the PIC micro controller [16].

In order to design it, first the load current need to measure in order to monitor it using current sensor including testing the fault (Over Current) and when such condition arise, it will isolate in the shortest time possible without harming the any other electrical devices[19], [20]. It will also including in developing the algorithm for instanta-

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neous over current relay and IDMT (Inverse Definite Minimum Time) relay for the circuit breaker to trip. In this thesis, PIC microcontroller will be used to control and operate the tripping coil in circuit breaker [13].

The objective of this paper is

1. To design and fabricate over current protection relay using PIC micro controller which can operate on the permissible conditions by setting the over current value.
2. To test unwanted conditions (over current) and when such conditions arise, to isolate the fault condition in the shortest time.

The scopes of the paper is,

1. To measure and analyze load current from current transformer sense. The load current (energizing current) will be measured by using current transformer and converted from analogue voltage to digital using PIC16F877A. Then the load current will display on the LCD.
2. Trip circuit breaker using PIC microcontroller.- The over current value is set in the PIC and when faults (over current)occur, PIC will energize the circuit breaker tripping coil which will cause the circuit breaker to trip[15].
3. Develop algorithm for instantaneous over current relay and IDMT relay. The over current setting may be given by definite time or inverse definite minimum time (IDMT) characteristic. There are four curves for over current complying with the IEC 255 and are named 'Normal Inverse', 'Very Inverse', 'Extremely Inverse' and 'Long Time Inverse'. This thesis is to develop the 'Long time Inverse' characteristic of IDMT.

2 CURRENT TRANSFORMER

The Current Transformer is a type of "instrument transformer" that is designed to produce an alternating current in its secondary winding which is proportional to the current being measured in its primary.

Fig-1: Current Transformer

A current transformer isolates the measuring instruments from what may be very high voltage in the monitored circuit. Figure 1 shows the current transformers are commonly used in metering and protective relays in the electrical power industry [11].

2.1 Numerical relay

Numerical relay is a special type of digital relay that actually uses the capability of the modern microcontroller to actually calculate the fault value and perform analysis such as Fourier Analysis on the fault data before even making decision to trip the system or not. Numerical relay also usually has the capability to record the faults value for analysis [3]. Most often these relay are also equipped with communication port that allows maintainer to download information from the relay after the fault has occurs or just for system health analysis purposes over currents. Either certain parameters of the model are computed assuming the measured signals or certain fraction of the terminal variables are computed based on all the remaining signals, and next compared

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to their measured counterparts. In the first case, the values of the calculated parameters differentiate internal faults from other disturbances [3], [12].

3 SPECIFICATION OF PIC 16F877A MICROCONTROLLER

As a programming language, BASIC is since long time ago known to the PC users to be the easiest and the most widespread one [14]. Nowadays this reputation is more and more being transferred onto the world of microcontrollers. From the Figure.2, PIC BASIC enables quicker and relatively easier program writing for PIC microcontrollers in comparison with the Microchip's assembling language MPASM [13]. As a result of a successful compilation of a PIC BASIC program the following files will be created.

1. BLINK.ASM - assembler file
2. BLINK.LST - program listing
3. BLINK.MAC - file with macros
4. BLINK.HEX - executable file

During the program writing, the programmer encounters always the same problems such as serial way of sending messages, writing of a variable on LCD display, generating of PWM signals etc. All for the purpose of facilitating programming, PIC BASIC contains its built -in commands intended for solving of the problems often encountered in praxis.

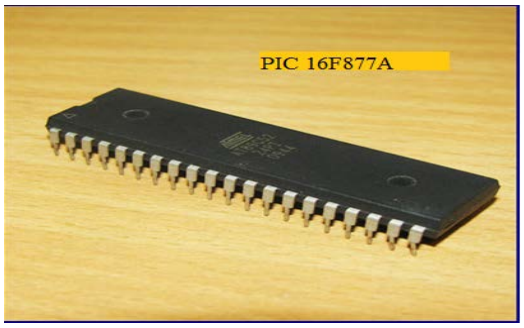

Fig- 2: Structure of PIC microcontroller (16f877A)

If the oscillator of the microcontroller is 4 MHz, (one single tact lasts 250 Nano-seconds), then one assembler instruction requires 250ns x 4 = 1µs for the execution. Each basic command is in effect the sequence of the assembler instructions and the exact time necessary for its execution may be obtained by simply summing up the times necessary for the execution of assembler instructions within one single basic command [13].

4 BLOCK DIAGRAM

The whole idea of this thesis is to isolate the 1 KVA transformers against over current by controlling the circuit breaker tripping coil using PIC microcontroller. Here current transformer is used at the secondary of 1 KVA transformer to measure the current and given it to I/V converter [19].Current transformer is used to measure the load current and will convert this current to certain voltage level as an input to microcontroller. As shown in Figure 3.

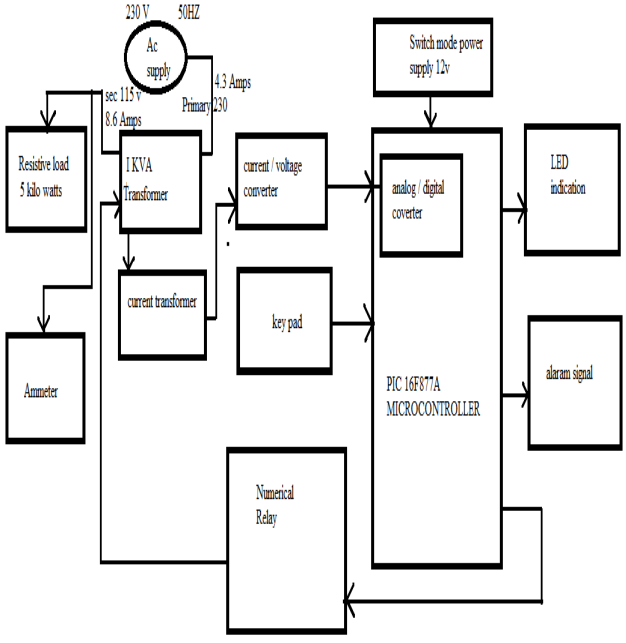

Fig- 3: Block Diagram of Over Current Protection of 1 KVA Transformer Using Numerical Relay

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Microcontroller will process and compare this voltage with desired voltage setting and will operate the tripping coil in circuit breaker if input voltage is greater than the setting value. Here the load is considered as the resistive load. If the load on the secondary increases up to 8 amps the control circuit makes the relay to operate. The capacity of transformer is a 1 KVA. On the secondary side of the 1 KVA transformer the current transformer is set up. The current transformer is used to measure the load side current value and then give current value to I/V converter [19]. The current value is converted into voltage value since the A/D converter accepts only the voltage value which is present in the PIC microcontroller. The PIC micro controller is used in this paper. It compares the set value with the input value of voltage and then if it is greater than the set value then it gives the indication by using LED. According to the condition the numerical relay operates.

5 SYSTEM DESCRIPTION

5.1 CIRCUIT DIAGRAM

Table- 1: Preset Value of Load Current of Transformer under Loading Condition

S.NO	Load setting Number of switches	Equivalent Set Value in Volts	Load current Reading in Amps
1	2	148	2.8
2	3	145	3.9
3	4	144	4.9
4	6	147	7
5	8	155	9

Figure 4 shows the circuit diagram of the over current protection of 1 KVA transformer with PIC microcontroller using numerical relay. The input to the transformer is given from the supply of 230 volt, 50 HZ supply. The transformer steps down to 115 volt. The secondary of the transformer is connected to the ammeter (0-10 Amps) to measure the load current. The current rating of primary and secondary is of 4.3 amps and 8.6 amps. The secondary of the transformer is connected to the load.

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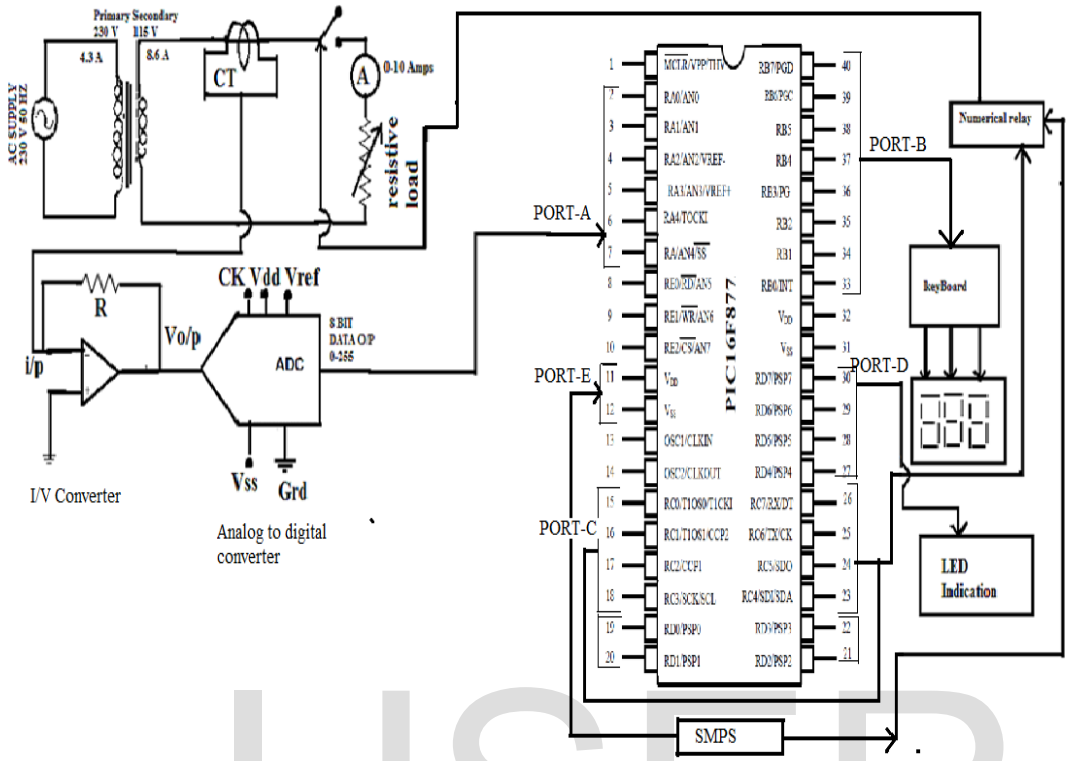

Fig- 4: Circuit Diagram of over current protection of 1 KVA Transformer with PIC Microcontroller using Numerical relay

A current transformer is used in the secondary side to measure the current value for the change in load and given as an input to the I/V converter which converts the current value to equivalent voltage value (0-5 volts). This in turn given to the A/D converter where the analog value of current is converted into 8 bit digital value (0-255). The 8 bit digital value is given as input to the microcontroller which will analyse the given input signal as programmed. When the load current is 6 Amps, the equivalent set value is represented by the voltage of 147. If further the load current is increased (8 Amps), the equivalent set value is increased (155) shown in table 1. The microcontroller is programmed in such a way that, if the input value exceeds the set value, this provides the signal to the Numerical relay and trips the circuit which will protect the transformer secondary against over current. This can also be monitored by means of LED indication and alarm indication.

5.2 System components and specification

1. Transformer rating 1KVA
2. Primary side voltage = 230V
3. Secondary side voltage = 115V
4. Current rating = 8.6 amps
5. PIC microcontroller details
    - 5.1 PIC number 16f877A
    - 5.2 40 pins
    - 5.3 Crystal oscillator
    - 5.4 5V DC supply
6. Current transformer (CT) =100/5 Amps
7. Numerical relay
8. Signal board

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9. Keyboard display
10. Switch mode power supply
    - 10.1 12-0-12 V transformer
    - 10.2 Switch mode power supply = 5 V
    - 10.3 PIC microcontroller = 5 V
    - 10.4 Numerical relay = 12 DC
11. Resistive Load = 5 KW

6 OUTPUT RESULT

Figure 5 shows the normal operation of the transformer with a resistive load of 8 Amps load and the operation of the circuit is explained in two cases:

CASE 1: In this case, the load on the secondary of the transformer is increased up to 6 Amps of load current by means of the equivalent set value given in table 6.1. In this condition the transformer operate under normal operation and the relay will not trip.

CASE 2: In this case the load is increased up to 8 Amps by means of load current which can be set by its equivalent value. Here, the set value is chosen in such a way that, if the load current exceeds the set value the relay operates and trips the circuit. Hence the relay operation protects the transformer from over current. This can be monitored by means of LED and an alarm signal [5].

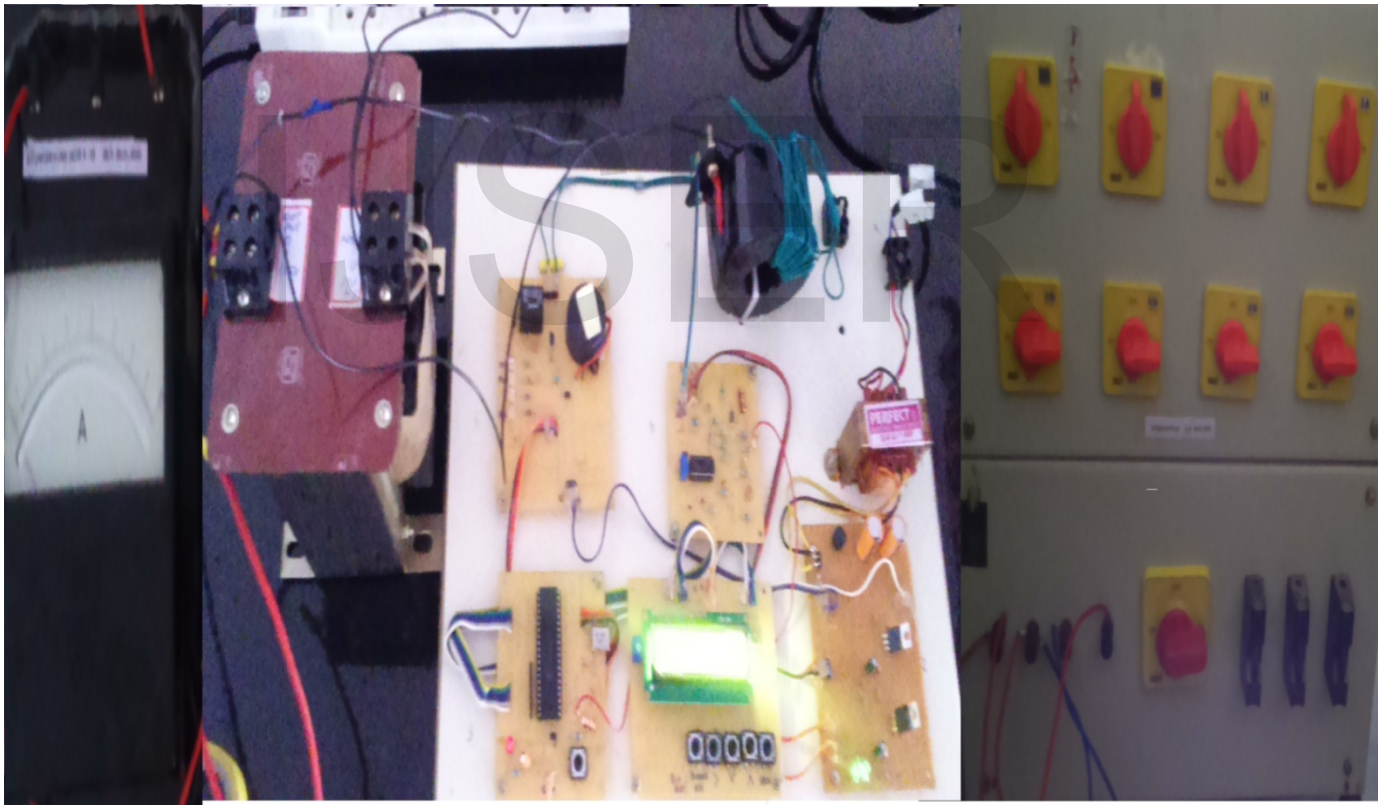

Fig- 5: Normal Condition of Transformer on Load with a set value of 6 amps

6 CONCLUSION

Whenever over current flows through the secondary of transformer the numerical relay will trip and protect the transformer. Numerical relay protection of the transformer is a very fast acting, when compared with other protection schemes. The power consumed by the control circuit is less and safety of the data transfer is increased. Protective re-

lays are essential for keeping faults in the system isolated and keep equipment from being damage. The time required to trip the circuit depends on the set value of load current given in PIC microcontroller. Transformer protection is a very important issue in electrical field and it is required to protect the other equipments in power system. This chapter is likely to approach the review about important part in the transformer protection system, which is of over current protection by numerical relay. Numerical relay which utilize with PIC microcontroller and is based on the most advanced technology and PIC is most Harvard chips are reduced instruction set computer and only few addressing modes. In future, the number of protection can be increased. Not only over current can be protected, other faults can also be sensed and protected by means of numerical relay.

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