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DISTRIBUTION TRANSFORMER OVERLOAD PROTECTION TRIPPING CIRCUIT

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ABSTRACT

Distribution transformer is an essential link in the distribution system. Failure of distribution transformers causes capital loss and loss of revenue to the nation. With the increasing loads, voltages and short-circuit duty of the distribution substation feeders, distribution over current protection has become more important today than it was even 10 years ago. The ability of the protective equipment to minimize damage when failures do occur and also to minimize service interruption time is demanded not only for economic reasons but also because the general public just expects "reliable" service. In distribution transformers, the loading on the secondary side increases sometimes due to increased power consumption. Due to this load draws more current from transformer than its rated value. If proper protection is not provided against this overload current then it damages the transformer insulation windings. An overload and fault protector for a distribution transformer or the like is disclosed. A series-connected high range current-limiting MCB is to be installed to protect the transformer from damages due to overloading by instantaneous tripping. It should withstand the initial magnetizing inrush current and should not trip during that period.

Keywords: Arduino, Circuit Breaker, Distribution Transformer, Overload

1. INTRODUCTION

Some times in pole mounted substations the loading on the secondary side of the distribution transformer increases due to increase in number of consumers or theft of electricity. In such cases, the load tends to draw more current from the transformer. The increased current increase thermal stresses in the winding of the transformer. This causes breakdown of the winding insulation, core damage and increased transformer losses.

2. MOULDED CASE CIRCUIT BREAKER

MCCB are currently used in all distribution transformer protection. A thermal circuit breaker is provided in series with the secondary winding of the transformer to protect it under such situations. The specifications of this circuit breaker are provided by the customer to the manufacturer in the tender. The main problem with MCCB is that it takes more time to trip. During this time winding can get damage due to excessive temperature. The following table depicts information about the tripping time for various percentage of overload. The circuit breaker shall have the following time/current characteristics and test will be made with all the three phases loaded. The reference calibration temperature of the breaker shall be 50 degree centigrade.

Table 1: Tripping Time for Various Overloads

Multiple of normal current setting	Tripping Time
1.05 (5%)	More than 2.5 hrs
1.1 (10%)	Less than 2.5 hrs
1.15 (15%)	More than 1 hr and less than 2 hrs

1.2 (20%)	More than 0.5 hrs and less than 1 hr
1.3 (30%)	Less than 20 minutes
1.4 (40%)	Less than 10 minutes
2.5 (150%)	Less than 1 minute
6.0 (500%)	Less than 5 seconds
8.0 (700%)	Less than 40 milliseconds
12.0 (1100%)	Instantaneous (less than 20 milliseconds)

3. MONETARY AND FINANCIAL LOSSES

The following calculations show the increment in costs to the customers due to delay in transformer MCCB tripping due to overload. This table shows the fixed costs for the repair of a transformer

Table 2: Repairing Cost of Transformer

Particulars	**Cost (in Rs.)**
Unloading charges + Transportation cost (from site to store)	400
Transportation cost (from store to factory)	400
Repairing charge (after guarantee period)	7000
Transportation cost (from factory to store)	400
Transportation cost(from store to site) + Loading charges	400
Total	**8600**

4. OBJECTIVES

The objectives of this project are:

- To design and fabricate over current protection relay using Arduino UNO microcontroller which can operate on the permissible conditions by setting the tripping value.
- To test unwanted conditions (overload) and when such conditions arise to isolate the fault condition in the shortest time possible.
- To investigate IDMT curve characteristic

5. METHODOLOGY

To overcome the problem of MCCB we are using electronic circuit breaker for better tripping time. In utility and industrial electric power transmission and distribution systems, an electronic circuit breaker uses a microcontroller with software-based protection algorithm for the detection of electrical or process faults. Such circuit breakers are also termed as microprocessor type protective relays. They are functional replacements for electromechanical protective circuit breakers and may include many protection functions in one unit, as well as providing metering, communication, and self-test functions.

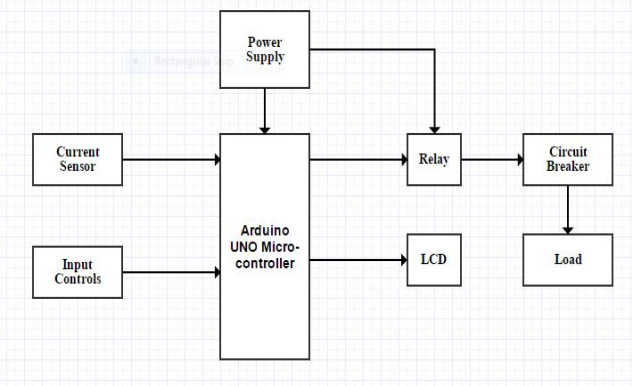

Figure 1 Block Diagram

An "Electronic Circuit Breaker" is a type of protective relay which operates when the load current exceeds a preset value. In a typical application the over load relay is used for over load protection, connected to a current sensor and calibrated to operate at or above a specific current level.

This project will attempt to design and fabricate over current protection relay using Arduino UNO microcontroller. The Arduino UNO microcontroller will cause the circuit breaker to trip when the current from load current reaches the setting value in the Arduino UNO microcontroller.

In order to design it, first the load current is needed to be measured in order to monitor it using current sensor including testing the fault and when such condition arise, it will isolate in the shortest time possible without harming any other electrical devices. It will also include developing the algorithm for instantaneous over current relay and IDMT (Inverse Definite Minimum Time) relay for the circuit breaker to trip. In this project, Arduino UNO microcontroller will be used to control and operate the tripping coil in circuit breaker.

It is to be noted that one second time delay is given before the Arduino UNO starts to monitor current. This time delay is to avoid nuisance tripping of circuit breaker when there is a flow of magnetizing inrush current when the distribution transformer is initially switched on.

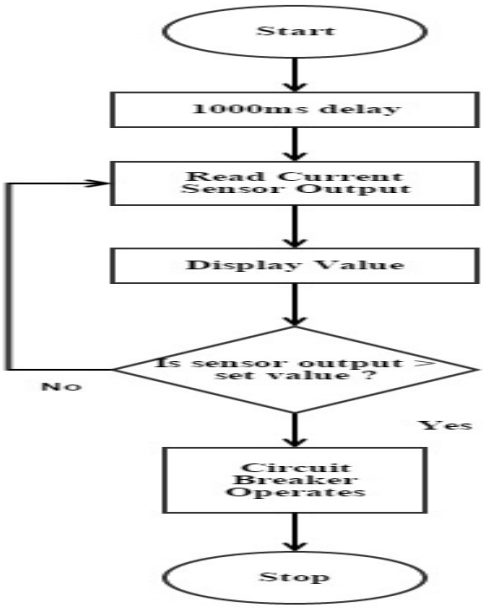

Figure 2 Flowchart (Program Logic)

6. PARTS OF THE ELECTRONIC CIRCUIT BREAKER

6.1 Hall Effect Sensor

Hall Effect sensor is the one of the type of magnetic sensor. A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced. Frequently, a Hall sensor is combined with circuitry that allows the device to act in a digital (on/off) mode, and may be called a switch in this configuration. The output of the hall sensor varies the supply current. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose.

6.2 Signal Conditioning Circuit

Signal conditioning means manipulating an analog signal in such a way that it meets the requirements of the next stage for further processing. Most common use is in analog-to-digital converters. In control engineering applications, it is common to have a sensing stage (which consists of a sensor), a signal conditioning stage (where usually amplification of the signal is done) and a processing stage (normally carried out by an ADC and a microcontroller). Operational amplifiers (op-amps) are commonly employed to carry out the amplification of the signal in the signal conditioning stage.

6.3 Controller Unit

Controller unit is the heart of the robot. For this project we used Arduino UNO microcontroller kit to control the circuit breaker according to the current sensor output. A program is written on the controller so that it collects the current sensor data and sends a message to the relay circuit that an overload has occurred and issues a trip command to it.

6.4 Power Supply

It is the major need for the circuit breaker to function in a proper manner. The circuit breaker, relay, microcontroller, display and controls needs 5V DC input for proper functioning. So 5V supply circuit is mounted on the circuit breaker.

6.5 Relay

It is an electromagnetic switch used to control the electrical devices. Relay is a passive device that can only be ON or OFF state by default. As such it does not actually know if when it should start to operate and when it should not. Active device that can actually "see" or sense the fault is required to instruct the relay on what to do. These devices are then connected to the relay input to make a mini protection scheme that can actually monitor faults and take necessary action. To be able to do a good job, the protection scheme should be able to eliminate the fault condition on the smallest portion of the circuit in the shortest time possible.

6.6 Circuit Breaker

A circuit breaker as a device designed to open and close a circuit by no automatic means, and to open the circuit automatically on a predetermined over current without damage to itself when properly applied within its rating. In addition, circuit breakers provide automatic over current protection of a circuit. Every circuit breaker has a specific ampere, voltage, and fault current interruption rating. The ampere rating defines the maximum current a circuit breaker can carry without tripping. The ratings of the circuit breaker depend on networks installed. The larger network the larger ratings

6.7 Display and Controls

The LCD displays the measured current from the distribution transformer. It also shows the pre-set value of the overload current. The control buttons will help to vary the value of the pre-set threshold overload current.

7. CONCLUSION

From this project we can

i. Measure and analyze load current from current sensor. The load current (energizing current) will be measured by using current sensor and converted from analog voltage to digital using Arduino UNO microcontroller. Then the load current will be displayed on the LCD.

ii. Trip circuit breaker using Arduino UNO microcontroller. The overload value is set in the microcontroller and when faults (over loading) occur, microcontroller will energize the circuit breaker tripping coil which will cause the circuit breaker to trip.

iii. Develop algorithm for instantaneous overload 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 project is to develop the 'Long time Inverse' characteristic of IDMT.

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