International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 04 | Apr 2023 www.irjet.net p-ISSN: 2395-0072

Differential Current Protection of Transformer using Arduino

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Abstract: *The Protection of the electric power network system is very important and essential for a dependable electrical power supply. Protection should be very fast and efficient as Electrical power systems experience faults for various reasons. These faults must be foreseen and safety precautions applied to the power system. Transformers, the heart of the power system save the world from darkness are to be protected is very essential. Transformers are the important parts of the power system. In this paper, we will use a differential relay mechanism with Arduino. By programming the Arduino, the protection of transformers is to be done. Programming is quite more efficient than the differential relay mechanism, so it is better to use Arduino instead of a differential relay. The working of the transformer is sensed & verified by Arduino every second. If Arduino finds any error i.e in an increase of current, temperature, and any abnormal function, then it sends a command to the circuit breaker to trip the main transformer. So, it is the efficient and best method to protect the transformers under abnormal conditions.*

Introduction:

The main important part of the power system network is the transformer as they do stepping up voltage and stepping down the voltage. The stepping of voltage is done at the power generating station and then power is transmitted at high voltage to reduce transmission loss. 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. In the design of electrical power transmission and distribution systems, various factors 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 essential for a dependable electrical power supply. Also, transformers are a critical and expensive component of the power system. The power systems engineer must include in his design, safety measures to avert any destructive occurrences that the system may undergo at any given time. Transformers are a critical and expensive component of the power system. They are considered the heart of the power system. Due to the long repair of and replacement of transformers, a major goal of transformer protection is limiting the damage to the faulted transformer. Protection against fault in the power system is essential for reliable performance. A power system is said to be faulty when an undesirable condition occurs in that power system, where the undesirable condition may be a short circuit, overcurrent, over-voltage, etc. For decades, fuses, circuit breakers, and electromechanical relays were used for the protection of power systems. The traditional protective fuses and electrometrical relays present several drawbacks. There are various ways are employed for the protection of transformer like over current, differential, etc. Each is employed for a different purpose. The type of protection for the transformers varies depending on the application and the importance of the transformer. Transformers are protected primarily against external as well as internal fault and overload. The type of protection scheme used should minimize the time for clearing fault and must discriminate between fault conditions and overload conditions. Here for internal fault differential protection scheme is used. Here in this scheme, we used Arduino with a voice announcement circuit and mechanical relay. Hereby using Arduino instead of a conventional relay gives many advantages like fast fault detection and clearing as well as cost reduction as in comparison with electromechanical and solid-state relays, Arduino based relay performs real-time computation which leads to enhancement in relay performance, facilitating faster, more secure protection for power transformer.

Differential protection

Differential current protection is the most reliable & popular technique in power system protection, works on the basic theory of Kirchhoff's current law. Fig.1 Differential relay mechanism with arduino as a main controller. This protection requires a set of current transformers & each compares the currents and calculates the difference between the two. Under normal operating conditions, currents in primary and secondary are the same. So, the proportionate voltages generated by the CTs on primary and secondary are the same. Whenever an internal fault occurs in the transformer the

currents sensed by the CT on primary and secondary differs by some amount. As a result, the voltage sensed by the Arduino from primary and secondary differs.

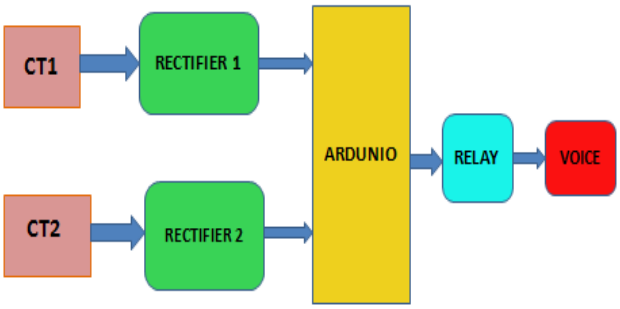
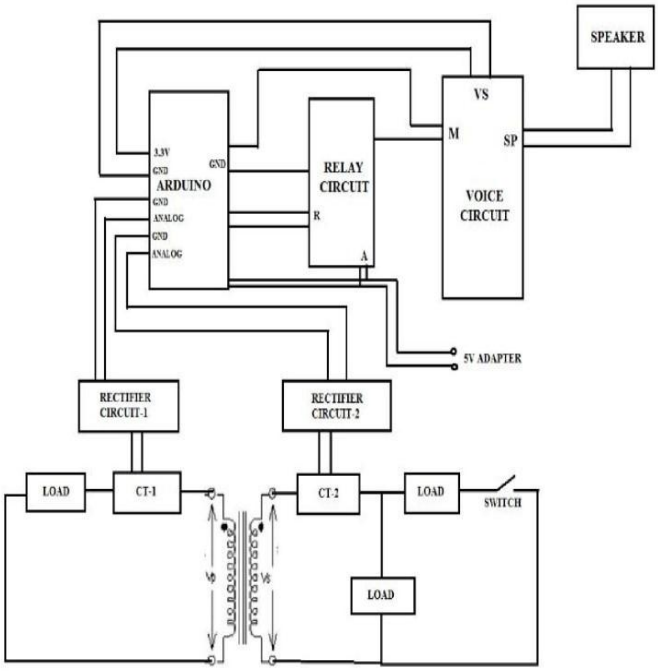


Fig.1 Differential relay mechanism with arduino



The circuit diagram of this protection is shown in fig.2

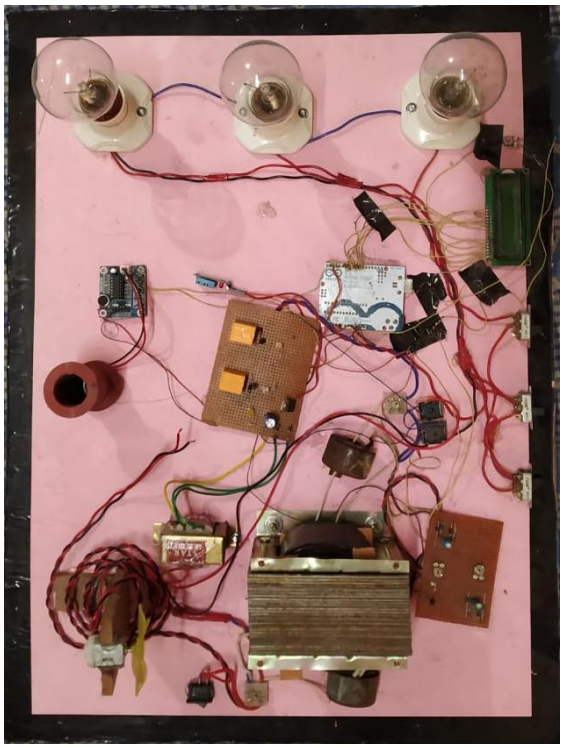


Figure 3 Top view of circuit

As seen in the circuit diagram figure 2 there are many components connected to perform properly. The input is fed to the primary of the isolation transformer used here instead of the power transformer. Two current transformers are used to sense the input current. Input is given to the transformer through the current transformer placed at the input terminal (CT-1).CT-1 senses the magnitude A.C fed to the primary isolation transformer and the current is then supplied to the rectifier to convert it into corresponding D.C and then D.C is sent to the Arduino board. After the input is fed to the transformer, the isolation transformer induces the same voltage in the secondary of the transformer then it passes through the current transformer connected to the secondary side of the transformer (CT-2). CT-2 senses the current in the secondary of the isolation transformer and passes it to rectifier circuit 2 which converts it to the corresponding D.C level which is fed to Arduino. Arduino after getting two input signals from two rectifier circuits for comparison. Arduino compares the two signals to find any difference between the input signals and if the difference is greater than pre-set value then Arduino sends a signal to the relay to shut the circuit. Arduino and voice circuit works on 5-20 v D.C supply. To get the D.C supply of 5-20 v a stepdown transformer is used in the circuit (220/12). The output of the stepdown transformer is then fed to the rectifier circuit to convert it to 12V D.C which is given to Arduino and voice circuit for their working. The loads are connected across 230 V A.C supply directly on the secondary of the transformer.

Each load is provided with a separate switch to operate. A Voice circuit is provided to give an alert at the certain differences in the primary and secondary current through a speaker. Relays control the loads and voice circuit. Arduino is the main component in this circuit. It is a single-board microcontroller programmed by using Arduino programming language (java). Arduino is used to comparing the currents on both primary and secondary. Two rectifier circuits are used in this circuit to convert the AC voltage into DC voltage for the use of Arduino. Current transformers also provided one on primary and another on secondary to tap the currents on both sides and to give proportionate voltage to the rectifier circuit. The output of the Arduino is connected to the relay. The relay here is a 12V DC 1-phase relay. Under normal operating conditions currents on primary and secondary are the same. So, the proportionate voltages generated by the current transformers on primary and secondary are the same. These two voltages are given to the Arduino. The proportionate voltages generated by current transformers are rectified by the rectifiers in the circuit. These two voltages will be the same in magnitude and the difference is zero. So, the Arduino gives no signal to the relay. Whenever extra load or an internal fault occurs in the transformer the currents sensed by the CT on primary and secondary differs by some amount. As a result, the voltage sensed by the Arduino from primary and secondary differs. As there is a difference in the voltage sensed by the Arduino i.e., the difference is not zero. Arduino, give a signal to the relay according to a predefined program. The relay is activated by the Arduino microcontroller the relay then activates the voice announcement circuit. The voice circuit will give the output a predefined voice as an alert to the operator. After three consecutive voice alerts Arduino will give a trip signal to the relay board. The Relay board is connected in series with the supply will open its contacts thus the supply to the hardware setup will be disconnected.

Software for program an Arduino

Algorithm N Software implementation

```
#include "DHT.h"
#include <LiquidCrystal.h>

LiquidCrystal lcd(6, 7, 8, 9, 10, 11);
int analogInput = 0;
float vout = 0.0;
float vin = 0.0;
float R1 = 100000.0; // resistance of R1 (100K) -see text!
float R2 = 10000.0; // resistance of R2 (10K) - see text!
int value = 0;

int k = 0;
int l = 0;

#define DHTPIN 2     // what digital pin we're connected to
// Uncomment whatever type you're using!
#define DHTTYPE DHT11   // DHT 11

DHT dht(DHTPIN, DHTTYPE);
int tt;

int relay1 = 3;
int relay2 = 4;

void setup() {
    pinMode(analogInput, INPUT);
  lcd.begin(16, 2);

  pinMode(relay1,OUTPUT);
  pinMode(relay2,OUTPUT);
  Serial.begin(9600);
  Serial.println("DHTxx test!");

  dht.begin();
}

void loop() {
  // Wait a few seconds between measurements.
  ttt();
  delay(100);
  vol();

  if(tt<34)
  {
   if(l==0)
   {
     lcd.setCursor(0, 0);
```

```
lcd.print("Temp =");
lcd.print(tt);
lcd.print("       ");
  digitalWrite(relay2,LOW);
  }
 }

 else if(tt>34)
 {
  l = 1;
  if(l==1)
  {
   lcd.setCursor(0, 0);

lcd.print("Temp =");
lcd.print("Max      ");
  digitalWrite(relay2,HIGH);
  }
 }

}
void ttt()
{

 delay(500);
```

// Reading temperature or humidity takes about 250 milliseconds!

RESULTS AND DISCUSSION

The mathematical calculations which are required at the various stages and the components used these rating have been mentioned below . The results focuses upon the tripping of the relay after the pre-determined limit and time taken for the same and the voice alert by the arduino before the final tripping.

Calculation

Voltage rating =230V

When switch 1 is closed, normal load = 29mA

When switch 2 is closed for alarm, load required for voice circuit ≈64mA

Time required by voice circuit to respond ≈2 seconds

When switch 3 is closed for overload, load required for tripping the relay to disconnect the supply to circuit ≈90mA

Time required to cutoff load ≈2 seconds

Temperature and humidity sensor DTH11 sensor

Temperature of transformer required for operating the fan =35 ^{o}C

Component Rating

1. Main Transformer = 1:1.
2. Turns ratio = 2.7 turns/volt.
3. Stepdown transformer = 12V/1A.
4. Bridge rectifiers =2 (used for conversion of ac to dc).
5. Rectifiers are adjusted using potential divider
6. Diode = 1A/50V.
7. 4 ON-OFF switches.
8. Relays = 3 12V/180Ω electromagnetic relays
9. DTH11—heat and humidity sensor.
10. Microcontroller board—328
11. 7805 voltage regulator IC
12. Npn transistor for relay operation

CONCLUSION, LIMITATIONS AND FUTURE

Applications

- Unbalance Caused by the Load Current
- Faults on LV Side of the Tapped Transformers
- Magnetizing Inrush Currents
- External Faults on HV System

Advantages.

- Ready to Use

Arduino is ready to use structure. As Arduino comes in a complete package form which includes the 5v regulator, a burner, an oscillator, a micro-controller, serial communication interface, LED and headers for the connections. A programming port is their on Arduino

board Just plug it into USB port of your computer and that's it.

Effortless functions

Some functions that make life incredibly simple can be seen while programming an Arduino. The automatic unit conversion feature of Arduino is another benefit. You could say that you don't have to bother about unit conversions while debugging. Just focus all of your effort on your projects' core components. There are no adverse effects to be concerned about.

Large community

On the internet, there are numerous forums where people discuss the Arduino. Arduino is widely used by professionals, enthusiasts, and engineers to create their creations. You can simply find assistance with anything. Additionally, every single function of Arduino is explained on the official Arduino website.

Easy to use

My belief is that if you began using micro-controllers with Arduino, it will be quite challenging for you to create sophisticated intelligent circuits in the future. A person cannot understand the fundamentals of many things, including as serial communication, ADC, and I2C, because of the simplicity of the Arduino hardware and software.

Therefore, we should sum up the benefit of Arduino by noting that while working on various projects, all you need to worry about is your creative concept. The rest will be handled by Arduno**.**

Limitations and Future recommendations

Transformer protection is a very crucial engineering principle. It is clear that the demand for electricity is increasing fast with increasing population and economic growth. This demands that more sophisticated transformer protection methods be used in the future in order to maintain a stable electrical power supply as will be demanded by the growing economy.

Based on the work done in this project, the future may demand that some improvements be made.

Some of the limitations faced in the design and future solutions include;

a) The current sensor does not offer a 100% sensing speed as needs some time do sense and transfer the signal to the microcontroller. A device with a faster sensing speed should be established.

b) Instead of using the relay as a switch, a semiconductor switching device such as a thyristor should be used.

c) Another limitation is that whereas the relay automatically recloses its contacts, the contactor used has to be restarted physically by an operator. Using a circuit that automatically recloses the system would be a great solution.

d) Lastly, the method of relaying the information to an operator in a control room far from the sub-station has not been explored in this project due to time constraint. An area for future study is how the system can automatically send a message to a control centre and notify the engineers of the exact location of a faulted transformer. A GSM module can be used in this case.

Conclusion

The main objective if this research paper has been to design and implement a system that uses an Arduino to protect a power transformer. This objective was achieved as the system works effectively. As the current circulating in the transformer coil varies, the LCD displays the readings. The relay is able to operate and isolate the transformer in case of an over current fault. The relay is the main switching element in the system. When energized, it opens its contacts and de-energizes the contactor thus isolating the transformer to safety in case of adverse current conditions. The other peripheral devices act as means of sending warning messages in case a fault occurs. This system if 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. Every customer desires to optimize the usage of a gadget yet at a low cost. The cost of implementing the system is relatively cheap as the components used are few and can be cheaply found in the market. The Arduino can be used to drive multiple relays using the same program. The only thing that needs to be done is free more ports for multiple input and outputs. This will allow for more variables from different transformers and multiple outputs to different relays.

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 explains why this system is needed and can help mitigate the effects of fault in a transformer.

In case an over current fault occurs, the power engineers should consider taking time to evaluate the possible cause of this phenomenon. For example, if there is an overload at the consumer end, there may be a call to install a new transformer that can withstand the increased load. The other mitigation option may be to add another supply line to the consumer so that the consumer demand is met.

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 transformers.

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