Differential Current Protection of Transformer using Arduino with Voice Alert

Sarfaraz Nawaz Syed

Department of Electrical and Electronics Engineering
GRIET, Hyderabad, Andhra Pradesh, India

S. Radhika

Department of Electrical and Electronics Engineering
GRIET, Hyderabad, Andhra Pradesh, India

M.N. Sandhya Rani

Department of Electrical and Electronics Engineering
GRIET, Hyderabad, Andhra Pradesh, India

Abstract— **Transformers are the important parts in the power system. So, development of better protection device for Transformers is essential. Differential relay technique can be employed to protect the Transformers. In this paper we have used differential relay mechanism with Arduino. By programming in the Arduino the protection of transformers can be done. Programming is quite efficient than differential relay mechanism, so it is better to use Arduino instead of differential relay. The working of transformer is verified by Arduino every time. It senses the condition of transformer each and every second. If it founds any error then it sends commands to the circuit breakers to trip the main potential transformer. So it is the efficient and best method to protect the transformers under abnormal conditions.**

Keywords — **Transformers, Differential Current Protection, Arduino Board.**

I: INTRODUCTION

Transformers are a critical and expensive component of the power system. Due to the long lead time for repair of and replacement of transformers, a major goal of transformer protection is limiting the damage to a faulted transformer. Some protection functions, such as over excitation protection and temperature-based protection may aid this goal by identifying operating conditions that may cause transformer failure. The comprehensive transformer protection provided by multiple function protective relays is appropriate for critical transformers of all applications. One of the most important pieces of equipment in power systems is the power transformer, which is used in different sizes, types, and connections. A power transformer functions as a node to connect 2 different voltage levels. Therefore, the continuity of its operation is of vital importance in maintaining the reliability of power supply. Any unscheduled repair work, especially replacement of a faulty transformer, is very expensive and time consuming.

A. Transformer protection schemes:

The type of protection for the transformers varies depending on the application and the importance of the transformer. Transformers are protected primarily against faults and overloads. The type of protection used should minimize the time of disconnection for faults within the transformer and to reduce the risk of failure to simplify eventual repair. Any extended operation of the transformer under abnormal condition such as faults or overloads compromises the life of the transformer, which means adequate protection should be provided for quicker isolation of the transformer under such conditions.
Various transformer protections are as follows:

1. Over current protection
2. Fused Protection
3. Differential Current Protection
4. Over Excitation Protection
5. Over Voltage Protection

According to many years of experience, differential protection provides the best overall protection for a power transformer. In principle, this protection scheme makes use of current difference flowing through different terminals of the transformer so as to distinguish between internal and external faults. It is also well recognized that differential current relays are affected by various factors such as inrush current, over-excitation, transformer tap changer operation, and current transformer (CT) saturation. For example, CT saturation leads to inaccurate current measurement and, therefore, may cause mal-operation of differential relays.

In addition, when the transformer tap changer is moved up and down with respect to the middle point at which the relay is adjusted to, the differential relay might initiate a trip signal without the presence of any fault. This mal-operation is caused by a spill current due to the impact of On Load Tap Changer (OLTC).

B. Current Differential Protection

Another common form of protection for apparatus such as transformers, generators, busses and power lines is current differential. This type of protection works on the basic theory of Kirchhoff's current law, which states that the sum of the currents entering and exiting a node will equal zero. Differential protection requires a set of current transformers (smaller transformers that transform currents down to a level which can be measured) at each compares the currents and calculates the difference between the two.

C. Arduino

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. Arduino is a single-board microcontroller designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open source hardware board designed around an 8-bit Atmel AVR microcontroller, though a new model has been designed around a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller.

The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring projects. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programming to the boards with a single click. Arduino programs are written in C or C++.It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on a external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. Arduino uno board is given in the Figure-1.
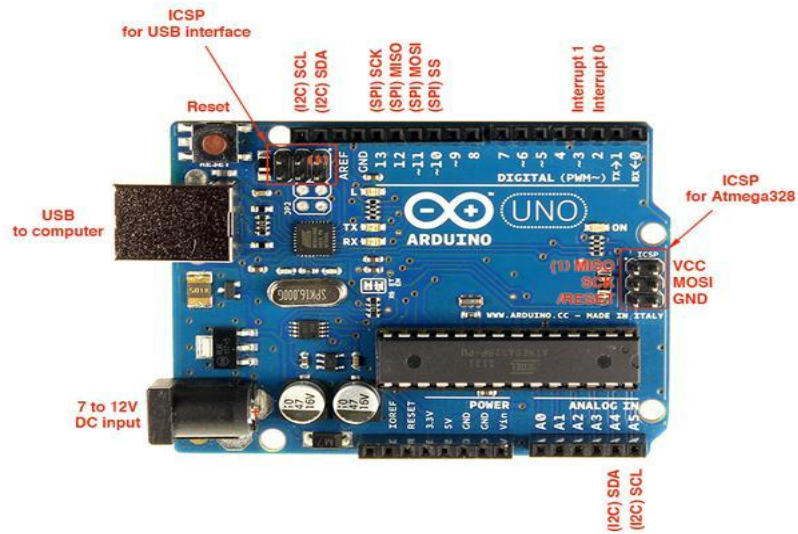
Figure-1: Arduino UNO Board
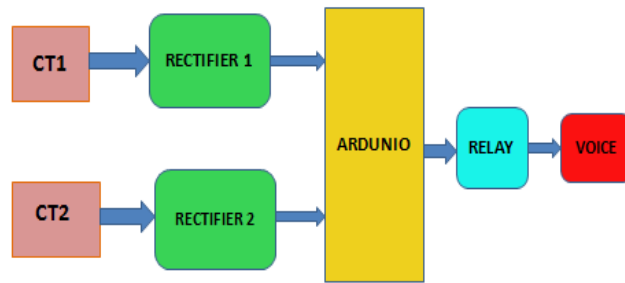
II CIRCUIT DIAGRAM

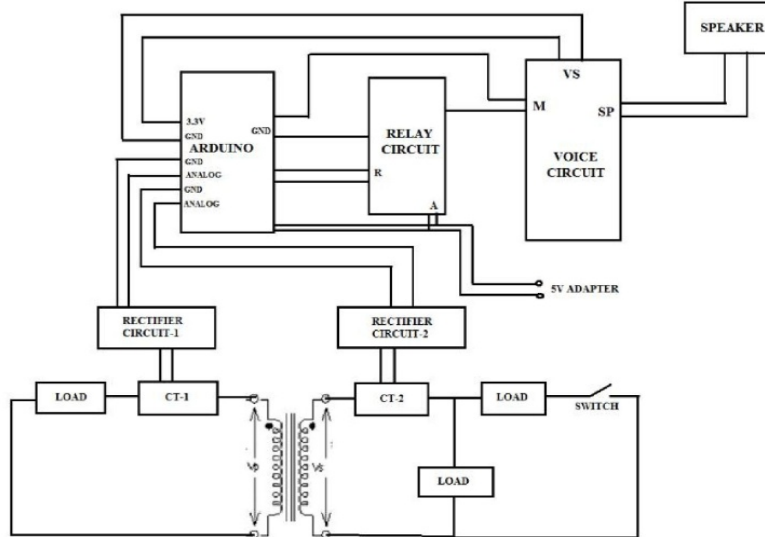Figure-2: Block Diagram Of Differential Protection Of Transformer Using Arduino

Figure 3- : Circuit Diagram of Differential Protection Of Transformer Using Arduino

A. Working:

Arduino is the main component in this circuit. Above figure shows the circuit diagram of the differential protection of transformer using arduino with voice announcement. Here arduino is used to compare 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 circuits. Output of the arduino is connected to the relay. The relay here is 12V DC 1-phase relay. Relay is used to initiate the voice circuit which gives voice alert.

Under normal operating conditions currents on primary and secondary are same. So, the proportionate voltages generated by the current transformers on primary and secondary are same. These two voltages will given to thearduino. The proportionate voltages generated by current transformers are rectified by the rectifiers in the circuit. Under normal operating conditions these two voltages will be same in magnitude and difference is zero. So, the arduino gives no signal to the relay.

Whenever extra load or an internal fault occur in transformer the currents seen by the CT on primary and secondary differs by same amount. As a result voltage sensed by the arduino from primary and secondary differs. As there is a difference in the voltage sensed by the arduino i.e., difference is not zero. Arduino give a signal to the relay according predefined program. As and when the relay is activated by the arduino the relay will activates the voice announcement circuit. The voice circuit will give output predefined voice as a alert to the operator. After three consecutive voice alerts Arduino will give trip signal to the relay board and which is connected in series with the supply will open its contacts thus the supply to the hardware setup will be disconnected.

III SOFTWARE

Arduino program:

```
int led = 13;
int voice_2=3; // the setup routine runs once
void setup( )
 {
Serial.begin(9600); // initialize serial communication at 9600 bits per second

pinMode(led, OUTPUT);
digitalWrite(led, HIGH); // turn the led on

delay(1000);// wait for a second

digitalWrite(led, LOW); // turn the led off

delay(1000);

digitalwrite(led, HIGH); // turn the led on

delay(1000);// wait for a second

digitalWrite(led, Low); // turn the led off

delay(1000);

Serial.println("Transformer Differential Protection");

}
// the loop routine runs over and over again
forever: void loop( )
{
// read the input on analog pin 0:
intCT1_P = analogRead(A0);
```

```
intCT1_S = analogRead(A1);
if(CT1_S > 700 && CT1_S > 850)
{
Serial.println("System OK")
delay(2000);
}
else if (CT1_S > 860)
{
Serial.println("Alert Faulty system");
Digitalwrite(voice_2,HIGH);
delay(700);
digitalwrite(voice_2, Low);
delay(2000);
}
Else
{
Serial.println("System OK");
 delay(2000);
}
}
```

IV. HARDWARE IMPLEMANTATION

List Of Components Used For This Project

1. Power transformer – 220/12 V & 12/220V(100VA)
2. Current transformers – 2
3. Switches – 1
4. Resistors – 2(1K ohms)
5. Arduino UNO board
6. Arduino software
7. Bulbs – 100W (2) & 60W(1)
8. Connecting wires
9. Screws and Bolts
10. 12V Relays - 2
11. Bridge Rectifier
12. Capacitors-470 micro farads(2)
13. Voltage regulator 7812
14. Transistor- 2N4923
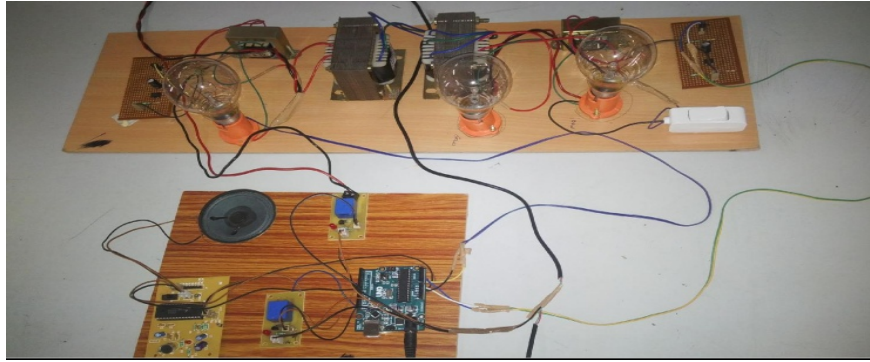15. Voice circuit board
16. Speaker

Figure-4: Hardware Setup of Diferential Protection Of Transformer Using Arduino
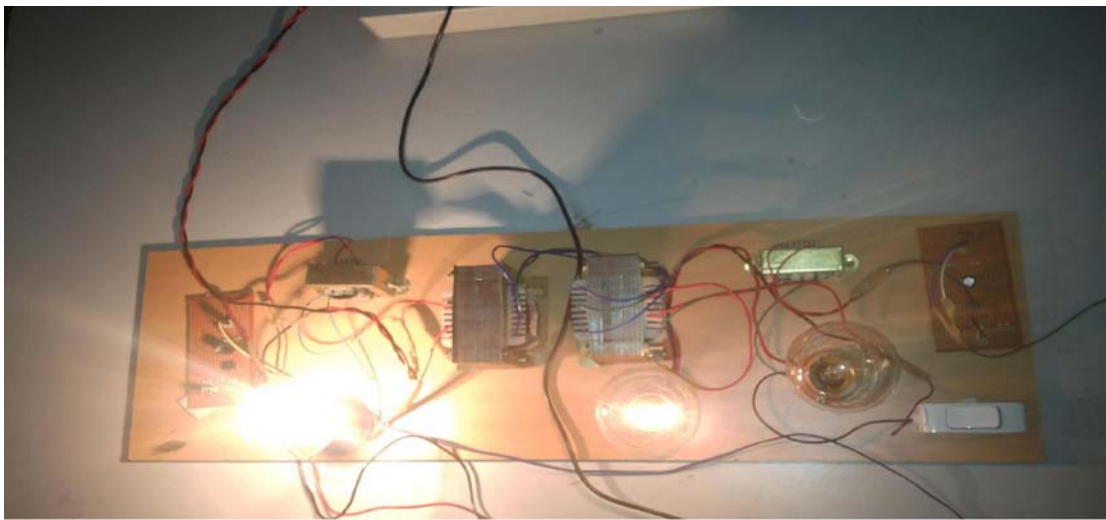

Figure-5: Hardware Setup Of Differential Protection Of Transformer Using Arduino Under Normal Condition
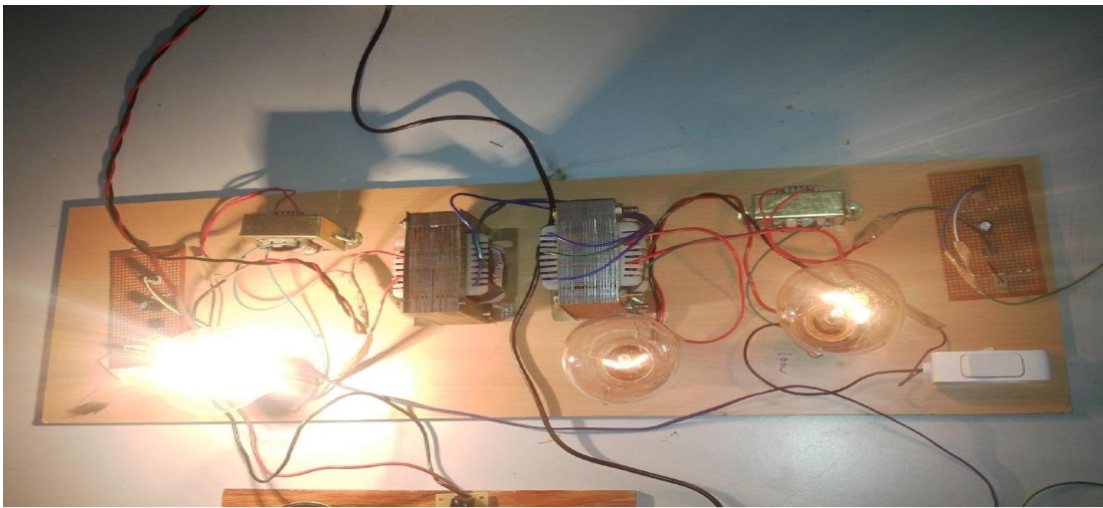

Figure-6: Hardware Setup Of Differential Protection Of Transformer Using Arduino Under Abnormal Condition

Voice Circuit

Figure-7: Voice Circuit

The APR33A series are powerful audio processor along with high performance audio analog to- digital converters (ADCs) and digital-to-analog converters (DACs). The APR33A series are a fully integrated solution offering high performance and unparalleled integration with analog input, digital processing and analog output functionality. The APR33A series incorporates all the functionality required to perform demanding audio/voice applications. High quality audio/voice systems with lower bill-of-material costs can be implemented with the APR33A series because of its integrated analog data converters and full suite of quality-enhancing features such as sample-rate convertor.

V.   CONCLUSIONS

Using Differential protection scheme, transformer is protected from faults with the use of Arduino operating an electromagnetic relay.
Future extension of this project is three phase differential protection of a transformer using Arduino.

ADVANTAGES:

1. Highly sensitive

2. Fit and Forget system

3. Low cost and reliable circuit

4. Complete elimination of manpower

APPLICATIONS

1. Unbalance Caused by the Load Current

2. Faults on LV Side of the Tapped Transformers

3. Magnetizing Inrush Currents

4. External Faults on HV System

VI.   FUTURE SCOPE

Future extension of this project is Differential protection scheme, can be implemented for three phase differential protection of a transformer using Arduino for number of transformers in a substation .

REFERENCES

[1]   Arduino Cookbook by Michael Margolis
[2]   Beginning Arduino Programming By Brian Evans
[3]   Arduino – Home Page. (2007, June 15). In Arduino Retrieved November 9, 2007, fromhttp://www.arduino.cc.
[4]   Arduino, http://arduino.cc/
[5]   Digi International Inc,XBee 11001 Bren Road East Minnetonka, MN 55343877912-3444 or 952 912-3444 http://www.digi.com
[6]   Power Electronics By Rashid & Ahmed.