

# Secure Drive: Real-Time Fault Detection in Three-Phase Motors Using Arduino and GSM

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**Abstract:** The aim of this research is making the protection system for the three-phase induction motor. Providing the protection system to the induction motor is very importance in industrial or commercial application as well as domestic application. In industry lots of operation like production, mixing, conveyor belts are not hampered owing to failure of any motor. The basic idea for the developing a project is to providing safety to industrial motor, lifts, pumps and giving alerts of which types of faults is produce to the operator or maintenance department. In this project we develop the three-phase induction Motor protection system which are over voltage, over current, under voltage, earth fault protection and over temperature with using micro controller. In additional also introduce the GSM alerts for which kind of faults are Produce at the Operation of motor.

**Keywords:** Three phase induction motor, Current, Voltage variation, Arduino.

## I. INTRODUCTION

The electric motor is most essential drive in present time or modern era of industrialization. Large number of ratings from 0 to 100 HP and above motors are used in home appliances and different industries. The fraction HP AC motor used for the different home application and large size and rating synchronous motor and induction motor of up to 10,000 HP used for different industrial application. These all motors should protect against the different fault. The faults are mainly two type which are Electrical and Mechanical. Electrical fault of motor occurs very much more compare to the mechanical damages. There are many types of electrical faults occurs in industries as well as home application. Like Over voltages, under voltages, over current, over load, over temperature, single phasing, over and under frequency, earth fault and many more. The motor characteristics must be very importance considerations in selecting the right motor protection system.

The abnormalities in motor and motor faults may appear due to mainly given below reasons.

1. Fault condition arise due to the external power supply network.
2. Fault condition arise due to the internal faults that is in the motor or in the driven plant.

Over voltages, under voltages, over, single phasing, over and under frequency and many more are coming under external power supply network fault category. The second category includes bearing failures, stator winding faults, over load, over current and motor earth faults etc. The degree of the three-phase induction motor protection depends on the costs and application of the electrical motor.

**Small Motor Protection System:** Many types of motors up to 30 HP are considered in small motor category. The providing protection of this type of motor is known as the small motor protection system. This type of motor protected by the HRC fuse, bimetallic relay and under voltages relay these all are included into the contactor and starter. Many case the common causes of the motor burn out on Low voltage fuse protected system is due to single phasing.

**Large Motor Protection System:** The motors above 30 HP rating are considered in large motor category. The providing protection of this type of motor is known as the large motor protection system. For this type motor we required to give the protection like bearing failure, over temperature, winding failure etc. Here we describe some fault condition of the motor.

**Over Current:** The ball and roller bearings are used for the motor application up to rating 500 HP and above this rating sleeve bearing are used. In industrial application many times frailer of the ball and bearing causes the motor to stop quickly from the running condition. Due to this, mechanical jamming in motor bearing and due to jamming of shaft of the motor drawn high current from the supply and damage the system as well as winding of the motor. Sometime motor burns out and damage the entire system.

**Motor over Temperature:** The motor becomes over heated due to the heating of the winding of the motor. The winding

of the motor is heated due to either of the mechanical over loading, by reducing the supply voltage and from single phasing of the supply network. The over temperature may cause deterioration of insulation life of motor hence it must be avoided by providing proper motor protection scheme. To avoid over temperature, the motor should be isolated in 40 to 50 minutes in the event of small overloads of the order of 10 percentage of full load. The protective relay should take into account the detrimental heating effects on the motor rotor due to negative sequence currents in the stator arising out of unbalance in supply voltage.

**Over voltage and under voltage:** In the power system we always look the continuity of the power is not constant there is vary from high to low. This variation of the voltage is due to the sudden change in the heavy load, lightening on transmission line, switching of the generation station and load etc. Due to the variation of the voltage the stress induced in winding and this stress may damage the insulation of the motor winding and the other equipment that is connected to these.

**Motor Earth Fault:** An Earth leakage fault of the motor is the fault that makes a path for the current to the ground. The path made from the one phase to the body of motor or directly through the neutral through the ground bypassing the load. This fault occurs due to the increase the stress on the winding of the motor due to over voltage and internal faults occur between the conductor and ground.

**Aim and Objectives of the Research:** The aim of this project is making the protection system for the three-phase induction motor. Providing the protection system to the induction motor is very important in industrial and commercial application. In industry many operations like production, mixing, and cutting, rolling, conveyor belt is not hampered owing to frailer of any motor. The basic idea for the developing a project is to provide safety to industrial motor, lift, pump and giving alert of which types of faults is produced to the operator or maintenance department. In the Power system networks, the supply voltages are unbalanced due to variation in the load and demand of power in industry and domestic application. The Faults is not predetermined that is produced when the variation is occurred in parameter. Our object of this project is to provide protection from these type fault condition and giving the alert of this fault to the operator or the maintenance engineering. We also track the record of the unhealthy condition and used for the future study.

**Problem Specification:** The problem occurs in motor or any rotating machinery, ranges, depending on the situation, from which application used. Some of problem seem to occur reputedly than others. Some problem could be avoided due to application and environment were understood, while some other may be caused by the change in the environment condition from where motor operates.

These problems include the following.

- Voltage variation
- Over current due to over load
- Overheating due to increasing temperature
- Earth leakage

## **II. LITERATURE REVIEW**

**Seungdeog Choi, Elham Pazouki, Jeihoon Baek, and Hamid Reza Bahrami [1]: “Iterative Condition Monitoring and Fault Diagnosis Scheme of Electric Motor for Harsh Industrial Application”** This paper presents a robust diagnosis technique by iteratively analyzing the pattern of multiple fault signatures in a motor current signal. It is mathematically and experimentally proved that the proposed diagnosis algorithm provides highly accurate monitoring performance while minimizing both false detection and miss detection rate under high noise and nonlinear machine operating condition. These results are verified on a digital-signal-processor-based motor drive system where motor control and fault diagnosis are performed in real time [1].

**Omar AlShorman, Fahad Alkhatni, Mahmoud Masadeh, Muhammad Irfan, Adam Glowacz , Faisal Althobiani, Jaroslaw Kozik and Witold Glowacz [2]: “Sounds and acoustic emission-based early fault diagnosis of induction motor: A review study”** Nowadays, condition-based maintenance (CBM) and fault diagnosis (FD) of rotating machinery (RM) has a vital role in the modern industrial world. However, the remaining useful life (RUL) of machinery is crucial for continuous monitoring and timely maintenance. Moreover, reduced maintenance costs, enhanced safety, efficiency, reliability, and availability are the main important industrial issues to maintain valuable and high-cost machinery. Undoubtedly, induction motor (IM) is considered to be a pivotal component in industrial machines. Recently, acoustic emission (AE) becomes a very accurate and efficient method for fault, leaks and fatigue detection and monitoring



by using uncontrolled bridge rectifier. The output from the bridge rectifier is not pure DC but we required pure DC supply for the Arduino board. The connection diagram of 12V power supply is shown below.

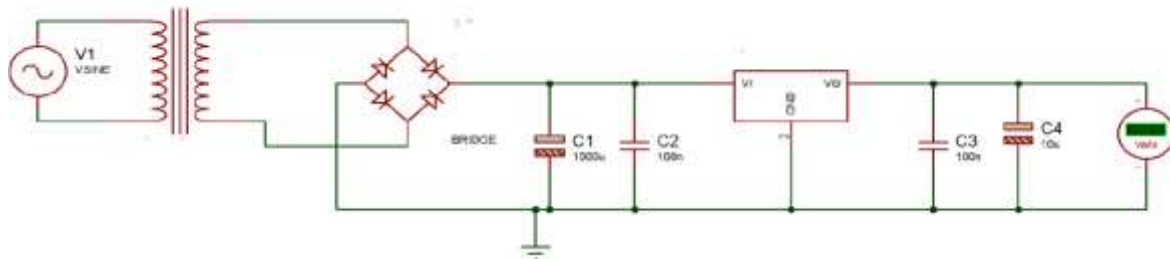


Fig. 2 12volt DC Supply

In electrical system, a capacitor is most widely used for the filtration process of ac quantity or for regulation purpose. Here the output from the bridge is not pure DC therefore the 1000µF/25V capacitor is used to reduce the AC quantity in the supply. The AC quantity contains the harmonics so for the reduction of this ceramic capacitor of 104 rating is used. Output from the bridge is not constant so voltage regulator is used. The LM7812 IC is regulating the voltage level of the DC voltage. After this again capacitor set is used for the harmonic reduction and AC quantity in wave form.

**LCD Interfacing:** LCD is the output device. Programs is required for the interfacing the LCD with Arduino. There are two types of LCD interfacing.

- 1) 8-bit mode in 8-bit mode, three control line and 8 data line is interface with Arduino board. Therefore, eleven digital pin is required to interfacing with the microcontroller board.
- 2) 8-bit mode in 4-bit mode, two control line and 4 data line is interface with Arduino board. Therefore, only total six digital pin is required to interfacing with the microcontroller board. Compare to 8-bit mode 4-bit mode is used. In 4-bit mode the data is sent in nibbles, first we send the higher nibble and then the lower nibble.

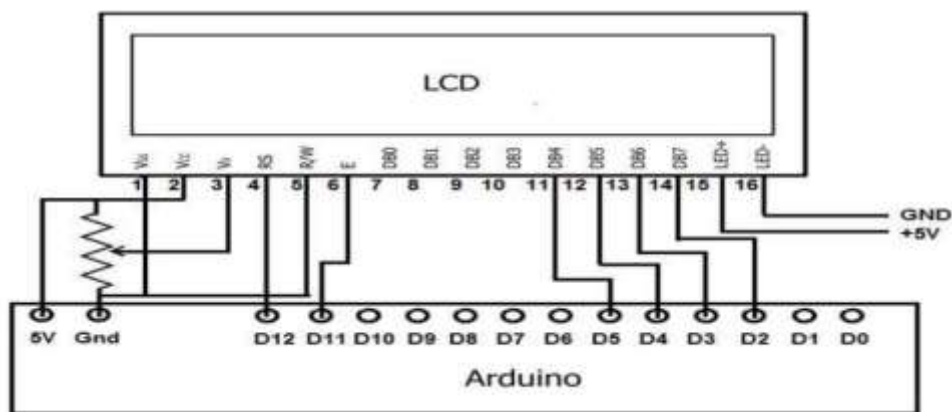


Fig. 2.2 LCD Interfacing

**Voltage Measurement circuits:** After the making the power supply Arduino is ready to interfacing with any circuit and uploading program of any circuit. Here we design a voltage measurement circuit to measure a line voltage of three phase supply in this circuit work on the principle is voltage divider rule. Here it is used because Arduino work on 5V dc supply only. So, we give any signal in 5V range. Therefor our voltage measuring signal is converted to 5v range using this voltage divider circuit. First, we convert 230 AC voltage supply in to 12V ac voltage supply using step-down transformer. After that conversion we convert 12V ac supply to dc supply using Rectifier Bridge. Here we used uncontrolled rectifier bridge. So, we connect a capacitor 1000µF that is eliminate the harmonics in supply and give pulse stating dc supply that pulsating dc supply is convert in pure dc supply. We connect parallel 100nF capacitor with 1000µF capacitor. That 100nF capacitor is give pure dc supply and also reduce ac component in the supply. Now 100nF capacitor with 470ohm resistor connects with series. Then after we collect output across resistor and give in Arduino. This is the analog signal for the Arduino. List of the use component is given below.

- 0-12/500mA transformer
- 1N4007 Diode

- 1000uF/25V Capacitor
- 104 ceramic capacitors
- 470 ohm and 100-ohm resistance
- V1=230 V AC, Bridge Output voltage is 15.6 V DC,

The circuit diagram of voltages measurement circuit is shown below.

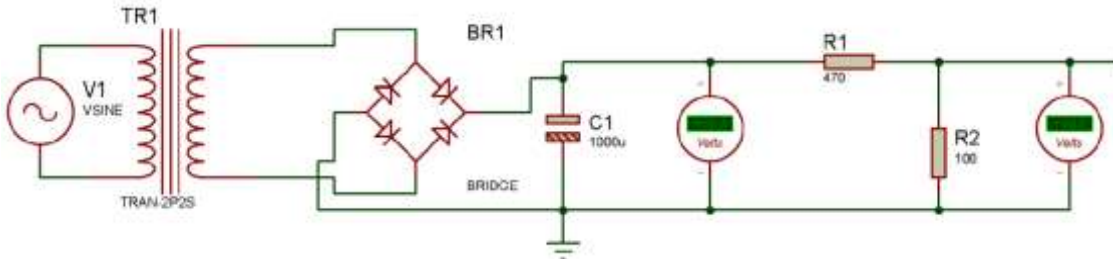


Fig. 2.3 Voltage Measurement circuit

#### IV. IMPLEMENTATION

##### Calculation:

- **Power Supply:**

V1=230 V AC, Transformer rating 0-12 V/ 1.5A, Bridge Output voltage is 15.6 V DC, charging time for capacitor is 0.01. Change in current with time is called Charge.

$$I = \frac{dq}{dt}$$

$$Q = 1.5 \times 0.01$$

$$= 0.015 \text{ C};$$

The capacitance is defined as, ratio of the change in electric charge in a system to the corresponding change in its electric potential.

$$C = \frac{dQ}{dV}$$

$$C = \frac{0.015}{15.6}$$

$$C = 9.6153 \times 10^{-4}$$

$$C = 961.538 \times 10^{-6}$$

$$C_1 = 961.53 \text{ uF}$$

So the value of c1 is select near about 961.53uF. Here we select the 1000uf/25 V because of output of bridge is 15.6 so 25 v is large compared to 15.6V.

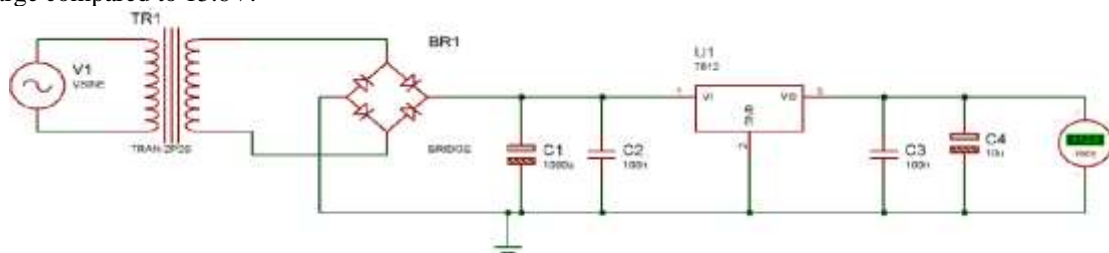


Fig. 3.1 Power Supply

**Voltage measurement:** V1=230 V AC, Transformer rating 0-12 V/ 0.5A, Bridge Output voltage is 15.6 V DC, Charging time for capacitor is 0.01.s.

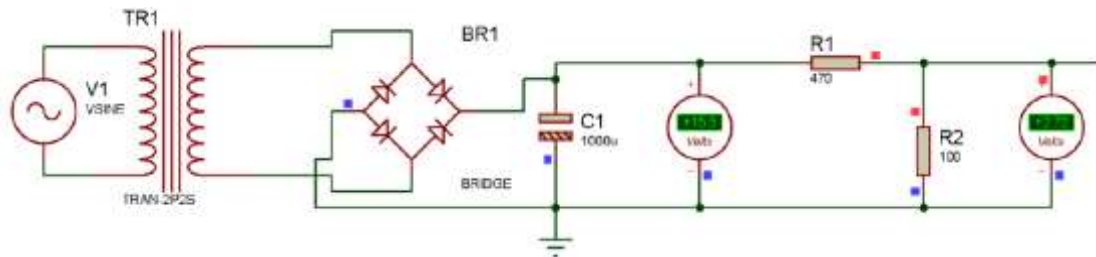


Fig. 3.1 Voltage measurement

Voltage across the capacitor 1 is 15.5V and current 0.5A. Now we required the analog signal for the Arduino and the range of that is form 0–5-volt DC. Here we required the down the voltage level. This can be achieved by using voltage divider rule.

Now tack the  $R1 = 470 \Omega$  and  $R2 = 100 \Omega$ .

$V_{C1} = 15.5V$ ,  $V_{R2} = ?$   $R1 = 470 \Omega$ ,  $R2 = 100 \Omega$

$$V_{R2} = \frac{R2}{R1+R2} * V_{C1}$$

$$V_{R2} = \frac{100}{470+100} * 15.5$$

$$V_{R2} = 2.66 \text{ V DC.}$$

This voltage is in range of analog signal. This output signal is directly fed to the analog signal of Arduino.

### Actual Implementation:

- **Simulation LCD Interfacing:**

- **Program:**

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(13,12,11,10,9,8); // RS,E,D4,D5,D6,D7
void setup()
{
    lcd.begin(16,2);
    lcd.setCursor(0,0); //0 column and 0 Row
    lcd.print("LCD SIMULATION");
    delay(1000);
    lcd.clear();
}
void loop ()
{
    lcd.setCursor(4,0);
    lcd.setCursor(0,0); //0 column and 0 Row
    lcd.print("PACIFIC SCHOOL");
    lcd.setCursor(0,1); //0 column and 0 Row
    lcd.print("OF ENGINEERING");
    delay(2000);
    lcd.clear();
    lcd.setCursor(0,0); //0 column and 0 Row
    lcd.print("SAGAR JAYDEEP");
    lcd.setCursor(0,1); //0 column and 0 Row
    lcd.print("CHANDRESH KARTIK");
    delay(1000);
    lcd.clear();
}
```

○ **Simulation:**

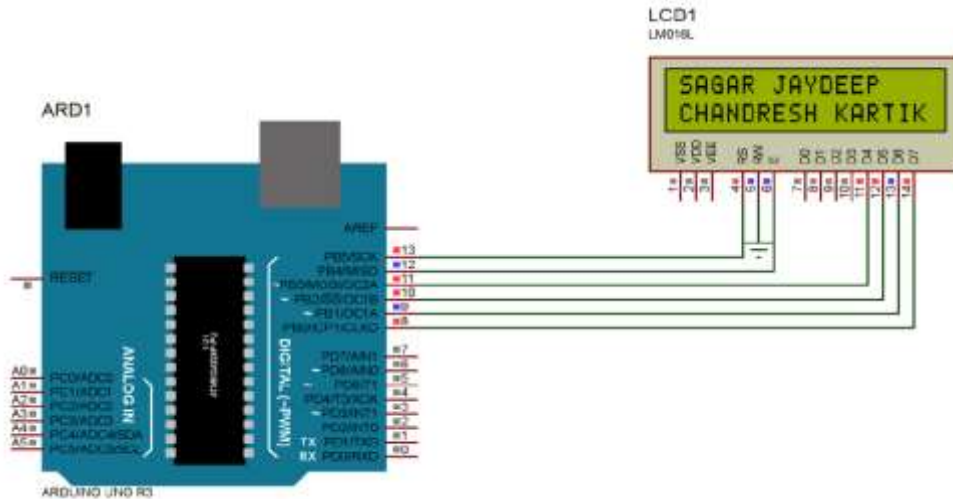


Fig. 3.2 (a) LCD Interfacing

● **Simulation Voltages Measurement**

○ **Program:**

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(13,12,11,10,9,8);
float VOLT;
unsigned int state;
void setup()
{
    lcd.begin(16,2);
    lcd.setCursor(0,0);
    lcd.print("volt: v");
}
void loop()
{
    state=analogRead(A0);
    VOLT=((state*420.0)/(1023.0));
    lcd.setCursor(5,0);
    lcd.print(VOLT);
}

```

○ **Simulation:**

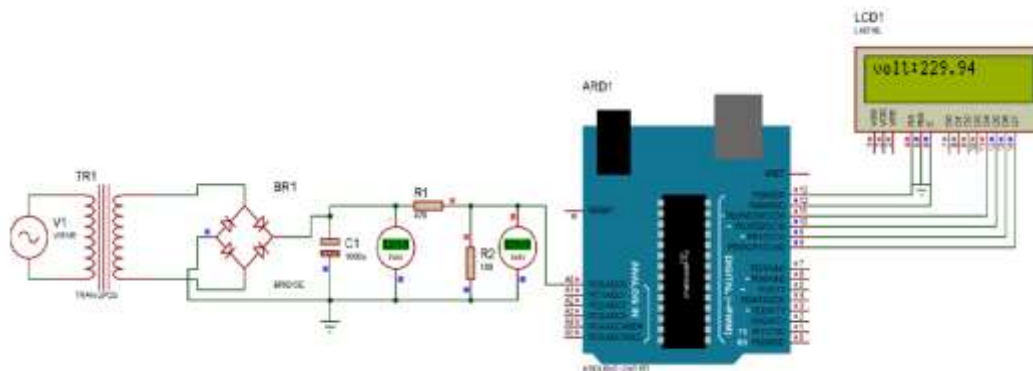


Fig. 3.2 (b) Voltages Measurement

● **Three Phase voltage Range measurement and Relay**

○ **Program:**

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(13,12,11,10,9,8);

```



```
float volt1,volt2,volt3;
const int relay1=7;
const int relay2=6;
const int relay3=5;
unsigned int state1,state2,state3;
void setup()
{
pinMode(relay1,INPUT);
pinMode(relay2,INPUT);
pinMode(relay3,INPUT);
digitalWrite(relay1,LOW);
digitalWrite(relay2,LOW);
digitalWrite(relay3,LOW);
lcd.begin(20,4);
lcd.setCursor(0,0);
lcd.print("R: V");
lcd.setCursor(0,1);
lcd.print("Y: V");
lcd.setCursor(0,2);
lcd.print("B: V");
}
void loop ()
{
delay(300);
state1=analogRead(A0);
volt1=((state1*230.0)/(506.0));
lcd.setCursor(3,0);
lcd.print(volt1);
if(volt1>=0 && volt1<=210)
{
delay(200);
digitalWrite(relay1,LOW);
lcd.setCursor(12,0);
lcd.print("R_UV");
}
if(volt1>210 && volt1<=240)
{
delay(200);
digitalWrite(relay1,HIGH);
lcd.setCursor(12,0);
lcd.print("R_VR");
}
if(volt1>240)
{
delay(200);
digitalWrite(relay1,LOW);
lcd.setCursor(12,0);
lcd.print("R_OV");
}
state2=analogRead(A1);
volt2=((state2*230.0)/(506.0));
lcd.setCursor(3,1);
lcd.print(volt2);
if(volt2>=0 && volt2<=210)
{
delay(200);
digitalWrite(relay2,LOW);
lcd.setCursor(12,1);
```



```
lcd.print("Y_UV");
}
if(volt2>210 && volt2<=240)
{
delay(200);
digitalWrite(relay2,HIGH);
lcd.setCursor(12,1);
lcd.print("Y_VR");
}
if(volt2>240)
{
delay(200);
digitalWrite(relay2,LOW);
lcd.setCursor(12,1);
lcd.print("Y_OV");
}
state3=analogRead(A2);
volt3=((state3*230.0)/(506.0));
lcd.setCursor(3,2);
lcd.print(volt3);
if(volt3>=0 && volt3<=210)
{
delay(200);
digitalWrite(relay3,LOW);
lcd.setCursor(12,2);
lcd.print("B_UV");
}
if(volt3>210 && volt3<=240)
{
delay(200);
digitalWrite(relay3,HIGH);
lcd.setCursor(12,2);
lcd.print("B_VR");
}
if(volt3>240)
{
delay(200);
digitalWrite(relay3,LOW);
lcd.setCursor(12,2);
lcd.print("B_OV");
}
}
```

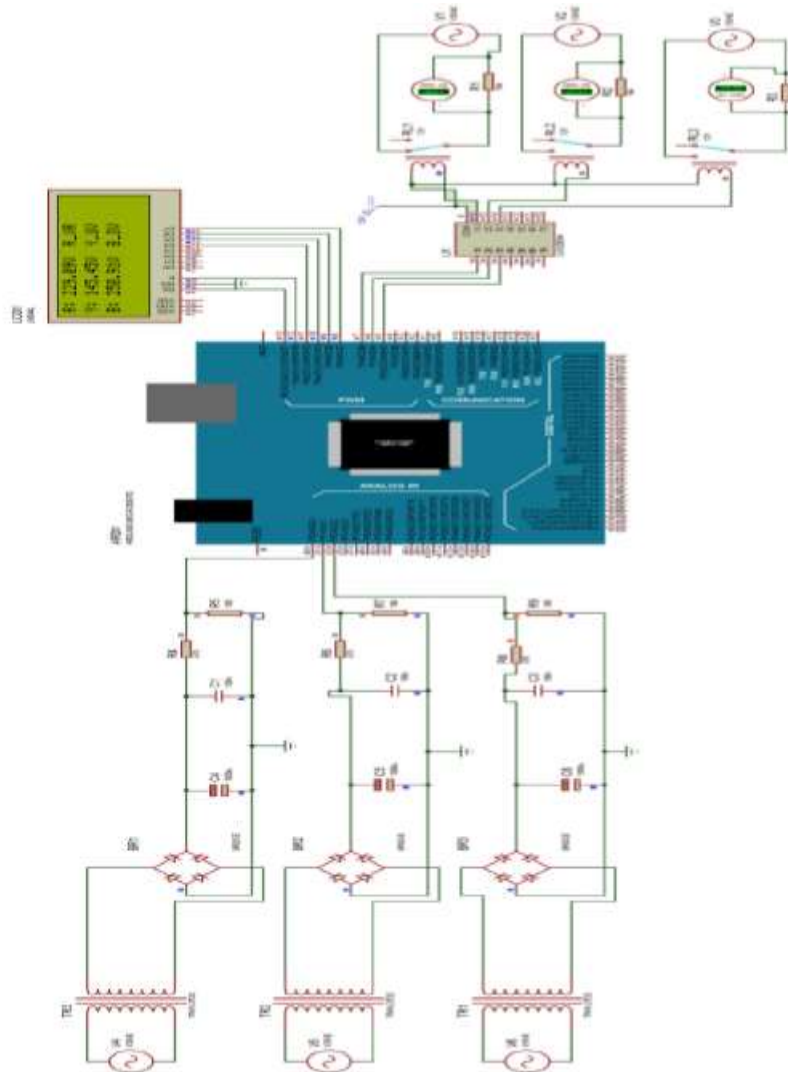
○ **Simulation:**

Fig. 3.2(c) Three Phase voltage Range measurement and Relay

**V. CONCLUSION****• Summary of results**

- In above project we made the 12-volt supply for the Arduino atmega2560 board. This circuit we first simulate in proteus software and after the analysis of output result, we implement that circuit on hardware. Here we get same results as we obtain from the simulation.
- In voltage measurement circuit we get same result as we simulate in proteus software and on hardware implementation. Some difference will occur due to internal error.

**• Advantages**

- This project through we develop the intelligent protection system to the motor operated in real industrial and domestic application.
- Main advantages of this protection system to give alert of fault to the operator. When the in industry large number of motors are operate at same time so it is not possible to care all motor at its position so this system is batter to use for protection as well as alert on which motor to be faulted.
- It is giving fast output in industries as well as reduce the maintenance cost.
- Also, it is more important for farmer because this project through we give SMS alert of power is come back.
- This system also we use in transformer protection system.

- This system through us improve accuracy in more expensive device production.

**• Future Scope**

- In future we will make over voltage, under voltage protection circuit. Once the voltage protection circuit is done than we include the GSM module.
- After this we make current measurement circuit and simulate on proteus software and then after construct the protection logic for over current protection.
- Our primary goal would be to produce a working prototype model of system on simulation software.
- After the making prototype next we will test this prototype with particular condition.

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