ARDUINO UNO BASED FAULT DETECTION, AND SPEED CONTROL SCHEME FOR SINGLE PHASE INDUCTION MOTOR

[1]**Santosh Kumar Bisoriya, ,**[2]**C.S.Sharma**
[1]M.E. Scholar,[2]Associate Professor & HOD of EE Department.
Department of Electrical Engineering ,Samrat Ashok Technological Institute, Vidisha (MP),INDIA

ABSTRACT- Today the most extensively used motor in the industry is the induction motor. The faults in the induction motor may lead to breakdown of the induction motor and an increase in expense to the industry. So in this paper we have discussed a system which is cheap as compared to the other systems and also cost effective. This system monitors parameters such as speed, temperature, current and voltage using an Arduino microcontroller. Using these parameters we can easily detect faults such as overvoltage, over- current, overload, excessive heating, crawling and under-voltage. The induction motor can be isolated from the supply in case of any of the faults with relays. The system also involves the use of a speed control system which can adjust the speed to desired value. This will reduce the need for additional motors because the same motor may be used to drive different devices. This system may lead to a huge amount of cost saving.

Keywords—Fault Detection, Overloading, Induction Motor, Speed Control

1.INTRODUCTION

An induction motor, especially squirrel cage induction motor is very reliable machine. The design of this motor enables the machine to work in various rough environments. It may experience various faults/abnormal conditions. The various faults include stator faults, rotor faults & bearing faults. All these faults have their own after effects. These after effects may be very hazardous to the motor if the fault is sustained for a long time. Therefore it becomes very important to clear a fault as soon as it occurs. So we need to have a system that detects the faults and isolates the motor from supply the as soon as they occur. An induction motor is generally termed as a constant speed motor. But under some circumstances it is necessary to change the speed of the motor so that it can be used for other applications. Hence we also need to have a speed control system so that a single motor can be used for more than one application.

The protection of induction motor plays an important role in its long life service. Researchers have done costly and limited protection for the stator windings protections, broken rotor bars protection, thermal protection etc. Mainly the induction motor needs protection from the variation of the input supply for small motors which is in common use not only in big industry but also in small scale industries. The small scale industries are not able to provide costly protection to the drives in use as it will increase their capital cost. Hence a cheap and compact design has been done for protection of induction motor against under voltage, over voltage, over current, under current. It has been also designed for critical loads which need to be run even under single phasing condition. Due to the poor power quality the damage of induction motors in small scale industries needs to be taken care of.

2.LITERATURE SURVEY

A. William H. Kersting [1] William H. Kersting stated that three phase induction motor can continue to run when one phase of the supply gone out of service. This may be due to any fuse blowing or opening of protective device of the motor, at step-down transformer or at feeder end. At this condition the three-phase induction motor continue to run but the motor will heat up quickly and it should be protected by removing it from the service at the instant of single phasing. When phase opens at step down transformer or at feeder end, the stator and rotor losses increases to ten times and the shaft output power decreases to negligible. But if the single phasing occurs at motor terminals the losses increases twice as compare to steady state losses and the shaft power reduces to nearly 70%. To protect the motor all the terminal should be open.

B. Sutherland P. E. [2] Sutherland P. E. and Short T.A. described that the for single phase fault the three phase reclosers are widely employed on distribution feeders. The majority faults are single phase. Its negative effect occurs on the other two phase customers, because the distribution line is mainly supplying the load to single phase customers. If three phase recloses did not open from the service, and the problem arises for three phase industry. On an average single phase fault occurs at 70%, two phase fault occurs at 20% and three phase fault occurrence is 10%.

C. Sudha M. and Abalagan [3] Sudha M. and Abalagan proposed a technique to save the three phase induction motor from single phasing. In this technique, PIC16F877 microcontroller has been used to sample the values of each phase and converted them to low voltage ac by means of transformer. The signals are converted to digital value using ADC converter. The controller continuously compares the digital value with the reference value and when the fault occurs, it opens the normally close contactor and disconnects it from the power supply. Single phasing, under voltage and over voltage protection is done practically on a 2kW motor and the motor is isolated if any of these condition occurs.

D. Pragasen Pillay et.dal.[4] Pragasen Pillay et.dal. Examines the three phase induction motor under the influence of under voltage and over voltage. The voltage at motor terminals may be higher than the nominal value in a complex industrial system and can be well below from nominal value in a heavily loaded industrial system. IEEE, NEMA and other power communities have different defined the voltage unbalance. The complex algebra is avoided in these definition.

3.FAULTS IN INDUCTION MOTOR

Any electrical system is affected by electrical & mechanical faults occurring in the system. The faults can lead to overloading, overheating and other effects. Every fault incident is indicated by the machine with various symptoms & behaviors. Faults in induction motors canbe categorized as follows:

3.1 Electrical faults: Some of the electrical faults are unbalance supply voltage or current, single phasing, under or over voltage of current, reverse phasesequence, earth fault, overload, inter-turn short-circuit fault, and crawling.

3.2 Mechanical faults: Some of the mechanical faults are broken rotor bar, mass unbalance, air gap eccentricity, bearing damage, rotor winding failure, and stator winding failure.

3.3Environmental faults: Some of the environmental conditions also affect the performance of the induction motor. These include ambient temperature, external moisture and vibrations of machine due to installation defect, foundation defect, etc.

Table 1: Fault occurrence possibilities of various faults ininduction motor.

Studied by	Bearing fault (%)	Stator fault (%)	Rotor fault (%)	Others (%)
IEEE	42	28	8	22
EPRI	41	36	9	14

Under EPRI sponsorship, a study was carried out by General Electric Company on the basis of data from motor manufacturer. It revealed the fault occurrence possibility of each type of fault in an induction motor. The results are tabulated in Table 1.

4:-SPEED CONTROL TECHNIQUES OF INDUCTION MOTOR

Speed control of the induction motor plays a very important role in some of the applications. Some of the speed control techniques of the induction motor include:

4.1 Stator voltage control: In this method the applied voltage across the stator is changed which changes the speed of the motor. This however changes the torque of the motor. This may be achieved by means ofresistance, inductance or the semiconductor devices.

4.2 Rotor resistance control: This method of speed control can be used in the slip ring induction motor only. Here the resistance can be added to the rotor in order to reduce the speed of the motor. This alsoincreases the starting torque of the motor.

4.3 Pole changing techniques: The synchronous speed of the motor is given by the formula:

$$Ns = 120*f/p \qquad (1)$$

Where Ns is the synchronous speed in rpm, f is frequency in Hz & p is no of poles. Hence changing the no of poles will change the synchronous speed which in turn changes the speed ofthe motor as

$$N = (1-s)*Ns \qquad (2)$$

Where N is speed of motor in rpm, s is the per unit slip &Ns is synchronous speed in rpm.

This may be achieved by:

a) Pole amplitude modulation
b) Multiple stator windings

4.4 V / f control or frequency control:
From equation 1 itis clear that the synchronous speed can be changed by changing the frequency and hence the speed of the motor will also change according to the equation 2. The emf induced is given by

$$E = 4.44*\varphi*f*T \qquad (3)$$

Where E is emf induced in Volts, φ is flux in webers, T isnumber of turns & f is frequency in Hz. Therefore a reduction in f will lead to an increase in flux which will lead to saturation of rotor and stator which will lead to higher magnetizing current. Hence φ should be kept constant which is done by maintaining the V/f ratio constant.

5. Proposed System

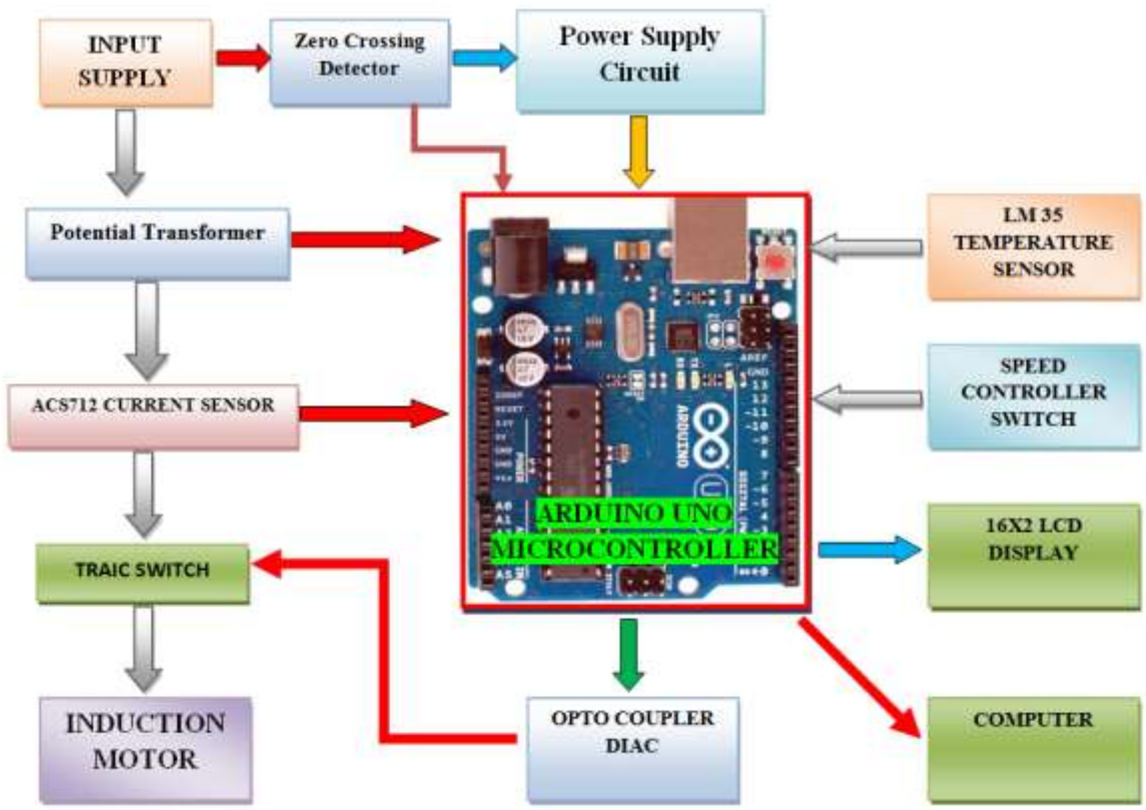

Figure1:- Proposed System Block Diagram

The block diagram is shown below in fig1. Arduino UNO is used with programming code which drives the whole system in conformity with their characteristic. Power supply is also used which supply the power to microcontroller. various section of the system explanation given as follows .

5.1 Fault Detection and Protection System

This system consists of various sensors and measurement circuits which measure the parameters of the motor continuously. These sensors have to be compatible with the Arduino i.e., their output voltage range should be between 0-5V DC. So, some of the sensors needs signal conditioning equipment as we are measuring the AC.

5.1.1:Current Measurement *:* In our system, current is measured using the ACS712 which can measure the current between +5A to -5A. It requires a 5V supply for its operation and itsoutput voltage varies linearly with respect to current. Its operation is based on the hall effect. This can be connected to one of the analog pins of the Arduino.

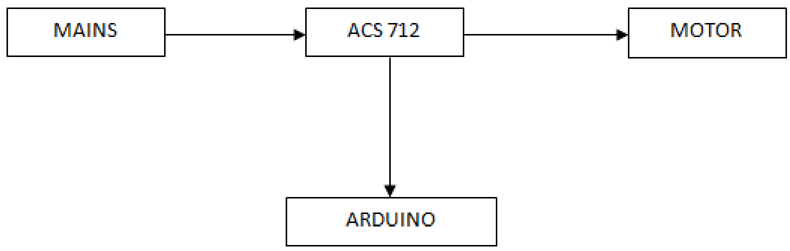

Fig 2: Current measurement block

As we have used the ACS712 it gives linear output voltage for current between +5A to -5A. An arduino analog channel converts the analog input voltage into a number between 0-1023. This means that for 0V the converted value would be 0 while for 5V it is 1023. Similarly +5A would be 1023 , - 5A would be 0 and 0A would be 512.

So for AC current measurement we would take samples for about 500 milliseconds. From these samples we will find the maximum value. Let the maximum value measured by the Arduino be Aim. Therefore the input RMS current I can be derived as follows:

Let Im be the max current.

$$Im = (Aim - 512)/512*5 \text{ A} \qquad (4)$$

Therefore I is given by

$$I = Im/\sqrt{2} \text{ A} \qquad (5)$$

5.1.2 Voltage Measurement : In our system, voltage is measured using the potential transformer whose ratings are 230V/12-0-12 V AC which can handle a current of about 500 mA.But this voltage is AC therefore we require a rectifier circuit for the conversion of AC into DC. This voltage still is greater than 5V. Hence we need a potential divider circuit in order to further reduce thevoltage to measurable range. This can be connected to one of the analog pins of the Arduino.

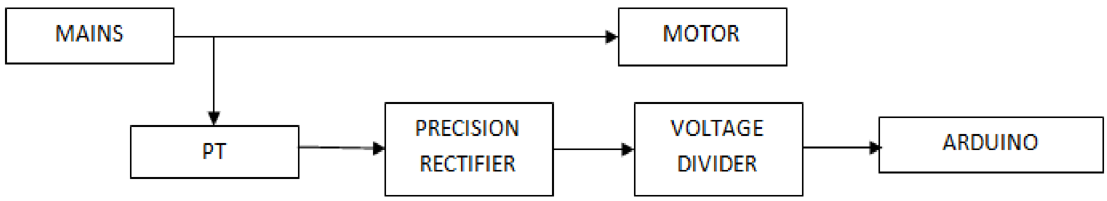

Fig 3: voltage measurement block

As we have used a potential transformer, rectifier and potential divider with ratio 3:1. The voltage will be in range 0-5V. An arduino analog channel converts the analog input voltage into a number between 0-1023. This means that for 0V the converted value would be 0 while for 5V it is 1023. So for AC voltage measurement we would take samples for about 500 milliseconds. From these samples we will find the maximum value. Let the maximum value measured by the arduino be A_{vm} . Therefore the input RMS current can be derived as follows:

Let Vm be the max voltage. Considering the PT ratio 230/12 and the potential divider ratio be 3:1 Vm is given by:

$$Vm = Avm/1023*5*230/12*3 \text{ V} \qquad (6)$$

Therefore V is given by

$$V = Vm/\sqrt{2} \text{ V} \qquad (7)$$

5.1.3 Temperature: In our system, temperature is measured using the LM 35 which also operates on a voltage of 5V. The range of the sensor is -55°C to 150°C. Its output voltage varies linearly with respect to current. This can be connected to one of the analog pins of the arduino.

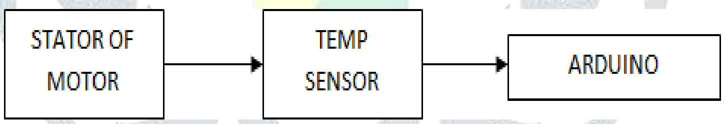

Fig 4: Temperature measurement

We have used LM 35 for the temperature measurement which gives a linear output voltage between the range -55oC - 150oC. Therefore let the analog value be At. The temperature is given by

$$T=At/1023*5*100 \text{ oC}$$

5.2 Speed Control System:

This system consists of potentiometer, Triac trigger circuit and zero crossing detector. The functions of the various components of the system are:

5.2.1 Potentiometer: This is provided for the user to set the firing angle of the Triac. The max firing angle can be set to 180.

5.2.2 TRIAC: The Triac is turned ON by the Triac triggering circuit. The Triac turns OFF by line commutation. The turning ON, if controlled properly will change the input RMS voltage of the motor.

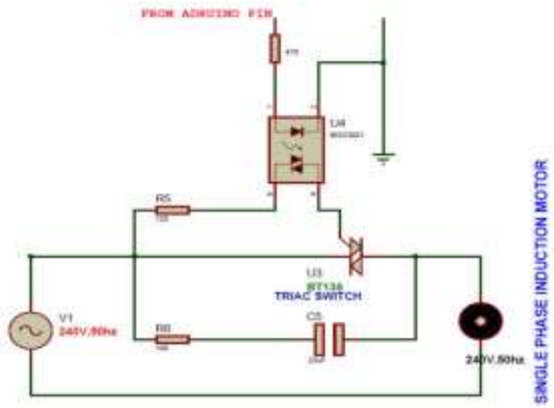

figure5:- Triac trigger circuit

5.2.3 Triac trigger circuit: The Triac trigger circuit is used to turn the Triac ON according to the firing angle set by the user on the potentiometer.

5.2.4 Zero crossing detector: The zero crossing detector provides a pulse to the arduino as soon as the AC waveform crosses 0. Due to this circuit the firing angle is measured from the zero. Due to this system the triggering angle is set according tothe user and hence the voltage of the circuit is varied due to which the speed of the motor is varied. This system also enables soft start of the motor.

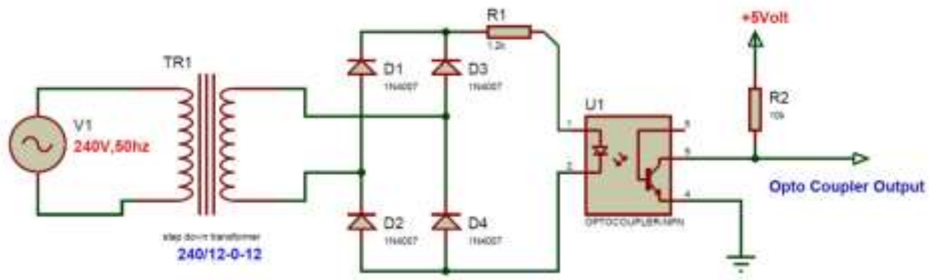

fig6:- Zero crossing detector circuit

5.3:-Data Logging System

In case a fault occurs and we need to analyze the parameters of the fault, then we have designed a data logging system which stores the parameters of the motor during fault into PC.

Fig 7: Data logging system

6. RESULT

The parameters are monitored by the Arduino continuously. Then it is checked whether the parameters are within the safe range. If the motor is within safe range and is approaching the values out of the safe range, then a warning is displayed on the LCD. If they are out of the safe range then the motor is isolated using the electromechanical relay and the fault which has occurred is displayed on the LCD. However if tests are to be carried out on the motor such as overvoltage test or under voltage test, then it is recommended that this system should be isolated from the motor. In this work , each sensors are tested individually and implemented . All electrical parameter of motor measured successfully through various sensor . All sensed data process through Arduino microcontroller and shows on 16X2 lcd display and serial monitor of the ARDUINO IDE. This system working well in various voltage condition . As voltage level goes above the dangerous level so system stoped induction motor in few micro second also auto shutdown in case of high voltage, over load, over temperature .

Figure08:- Phase Voltage Display On Lcd

Figure09:- Temperature And Speed Display On Lcd

7. CONCLUSION

The dissertation is based on the protection of induction motor under, over voltage, under voltage, overloading, over temperature and it is implemented using Arduino uno controller, step down transformers, potential transformers, sensing circuits and optocoupler . The system is very cheap as compared to present protective devices available. The protection system can protect induction motor from under voltage, over voltage, overloading and over temperature . By using sensing circuits we can sense voltage and current and these values given to controller. Controller will give the command to relay to ON-OFF the motor. for controlling speed of induction motor TRIAC switch use and firing angle can be controlled through potentiometer .

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