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INDUCTION MOTOR PROTECTION FORM UNBALANCED VOLTAGE AND OVER LOAD USING MICROCONTROLLER

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ABSTRACT
Protection of three phase induction motor has been done using the microcontroller, overload relay and step down transformer. This protection scheme protects the three phase induction motor from unbalanced voltage source such as: under voltage, over voltage and over current. The overall process is monitored by microcontroller. Microcontroller sends signal through transistor to relay for operation. This microcontroller can sense 8 analog inputs up to 5V. Three analog inputs of microcontroller have been used for three phase voltages for conversion to digital signal. The remaining inputs can be used for receiving the information from motor such as temperature, speed etc. Step down transformer is (220V/12V). The output of these transformers will vary proportionately with respect to its input. The microcontroller senses the voltage, compares with the reference value and sends control signals to the respective protective relays. The overall system is cheap and reliable. It has been tested several times and gives the good results. In this protection system, the limits for the voltages and currents have been taken as +10% and +30% respectively for 3 seconds. If any phase voltage or current goes beyond its limit, the microcontroller will send trip signal to all the three relays simultaneously so that the motor is disconnected from the power supply.

KEYWORDS: *induction motor, microcontroller, unbalanced voltage supply, overload relay, transformer.*

INTRODUCTION

Induction motor is the most widely used motor in the industry due to its simple and rugged construction. It requires least maintenance as compare to the other electrical motors. Induction motor protection control is now a days more easy and versatile due to the advancement in the field of power electronics and hence is easy to replace other costly

and controllable motors. The protection of induction motor plays an important role in its long life service. Researchers have done their research to minimize cost for maintenance by designing appropriate circuit for the stator windings protection, broken rotor bars protection, thermal protection of induction motor etc. Mainly the induction motor needs protection from the variation of the input supply voltage for small motors which is common use not only in big industry but also in small scale industries. If small scale industries are not able to provide sustainable protection to their drives, then it will increase their maintenance cost. Due to this they should design cheap and compact protection for induction motor against unbalance voltages, under voltage, over voltage, short circuit and thermal protection. It also designs for critical loads which need to be run even under single phasing condition. Due to the poor power quality the damage of induction motors also needs to be taken care of. The overall cost of the protection equipment should not be more than 15% of the total cost of the actual machine. Keeping this in mind the design has been proposed using 16- bit microcontroller, transistor, relays, overload relay and step down transformer, so that the overall cost is low. But the efficiency of the protection scheme should not be compromised.

Objective

The main objective: induction motor protection from unbalanced voltage and overload.

The specific objective:

- To make a cheap and reliable protection system for three phase induction motor.
- To protect the motor from phase failure.
- To reduce maintenance cost of induction motor.
- To reduce manual operation.

Statement of the Problem

This project develops a fault detection method for three-phase induction motors to detect faults in all over circuit of the induction motor by using microcontroller and overload relay technique. The thermal protection for induction motors fed by motor control devices is great importance for the reliable protection of induction Motors, increasing the service time of the motor, and reducing the extra financial losses due to maintenance. It is also difficult to protect the motor manually from unbalance voltage and over load, but using microcontroller it is possible to control unbalance voltage and over load by adjust rated operation value voltage and current of motors.

Three phase induction motor can continue to run one phase of the supply gone out of service. The motor heat up quickly and damage.

When we see in the internship period the main problem of the company the relay or the coil does not close even if below the minimum rated voltage, at that time the motor is run but not normal condition.so the project it protect and fix the above problem.

Significance of the Study

Induction motors are the most common electrical machines, because of their relatively low manufacturing cost and the easy of control. They represent about 80% of the electro mechanical energy conversion machines. As indicated before, Identifying faults in these motors and protecting them is an important aspect to reduce loss and cost.

Microcontroller based techniques is used to identify these faults and to take action to correct the faults. It reduces the manual system of the protection of induction motor from unbalanced voltage source.

Scope of the project

There are two scopes in this project which is hardware and software development.

For the first scope which is hardware development are two main sections.

- Designing bridge rectifier to get a desired DC voltage.
- Interfacing devices with microcontroller (pic 16F877A).

For the second scope which is software development, there are two sections.

- Write a program on MIKROC software.
- Simulate design on Proetus software.

METHODOLOGY

The methodology used to address the research problem is described in this chapter. Study Restate problem and objectives of the project. The next section describes the procedures used for this study which includes a detailed account of microcontroller technique. The MICRO C software used for implementing the techniques is also described in this section.

This project gives an artificial intelligence protective methods and their application in fault identification. Three-phase induction motors are the most popularly used motors especially in industry because of their reliability and simplicity. These motors experience different types of faults during their operation.

These faults are:
Over loading, single phasing, Unbalanced supply voltage, under voltage and over voltage
A brief description of these faults and their characteristics is given below.

Protection of these motors is an important task which has been challenging to engineers. Protective relays were used to monitor the faults and disconnect the motor in case of a fault.

Overloading: Overload fault occurs when the mechanical torque exceeds the threshold point by applying mechanical load to the motor greater than full load rating. Overloading causes increase in phase currents, over heating the machine. In a traditional relay protection system, the overcurrent relay trips the motor off-line when the over load encounter over current in the line.

Single phasing: Single phasing is one of the unbalanced cases of the motor. It occurs when one of the three lines are open. More current flows through the other two lines and more heat is generated in stator winding. In the traditional protection systems, a high-set instantaneous trip unit relay is used. Single phasing also gives rise to negative sequence current. A negative sequence relay can also be used to protect against this fault [9].

Unbalanced supply voltage: There are many causes of unbalance supply voltages such as unbalance loading, open delta transformers and unequal tap setting. This condition leads to reduction in motor efficiency, raises the motor temperature and excessive unbalanced full load current.

Under Voltage: Under voltage fault is reducing the supply voltage on the three phases by specific Percentage, which makes the motor from attaining rated speed in specified time, increases the Current and overheats the machine. Low voltage protection relays are used in traditional systems. However, in order to avoid unwanted relay shutdowns due to momentary voltage drops, the AC contacts need a delay mechanism which delays the under voltage protection for a time period.

Over Voltage: Over voltage occur if the three phase voltages are greater than rated voltage. The effect of this fault is increasing current flow which leads unacceptable stress on the motor insulation due to high heat dissipation. Conventional protection systems use the over voltage relays to protection the motor during this condition [1].

BLOCK DIAGRAM

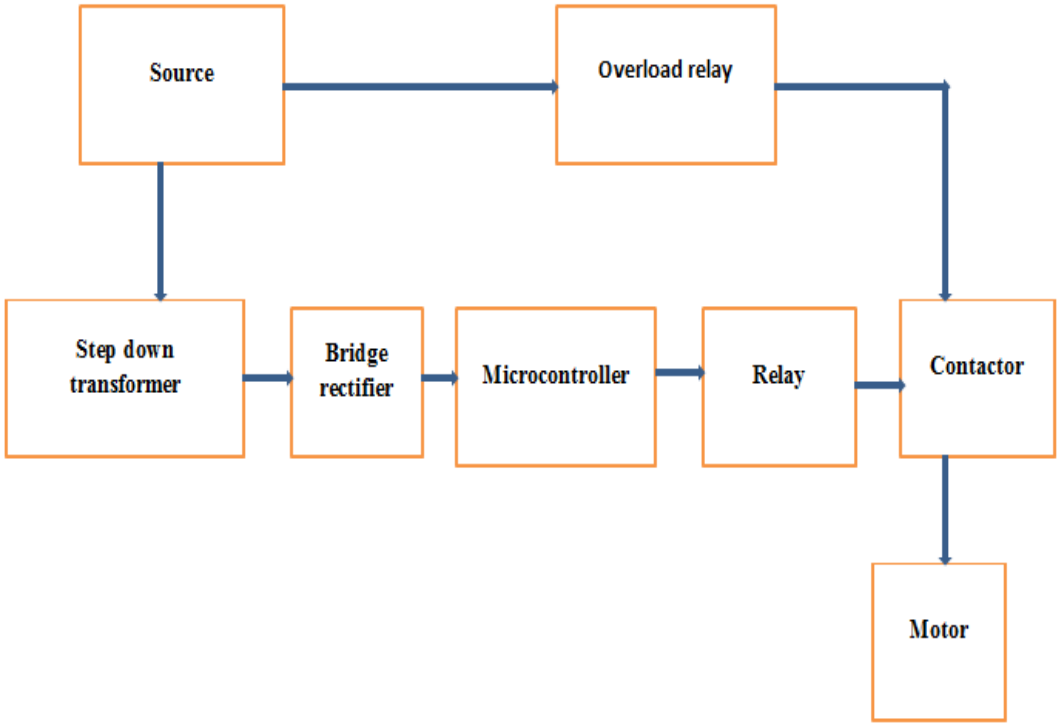

Figure 1: block diagram

1. Microprocessors & Microcontrollers

A single chip computer or A CPU with all the peripherals like RAM, ROM, I/O Ports, Timers, ADCs etc. on the same chip.

A CPU built into a single VLSI chip is called a microprocessor. It is a general-purpose device and additional external circuitry is added to make it a microcomputer. The microprocessor contains arithmetic and logic unit (ALU), Instruction decoder and control unit, Instruction register, Program counter (PC), clock circuit (internal or external), reset circuit (internal or external) and registers. But the microprocessor has no on chip I/O Ports, Timers, Memory etc.

Pic Micro Controllers

The term PIC stands for Peripheral Interface Controller. It is the brain child of Microchip Technology. Originally this was developed as a supporting device for programmable data processor (PDP) computers to control its peripheral devices, and therefore named as PIC, Peripheral Interface controller.

They have coined this name to identify their single chip micro controllers. These 8-bit micro controllers have become very important now a days in industrial automation and embedded applications etc.

These µcs are available with a range of capabilities packaged in both dual in-line packages (DIP) and surface-mount packages. These are available in 28 pin DIP, 40 pin DIP, 44 pin surface mount package etc. Some of PIC controllers contain the letter A in their number. The presence of A indicates the brown-out reset feature, which causes a reset of the PIC when the Power Supply voltage drops below 4.0v.

A decade back the process and control operations were totally implemented by the Microprocessors only. But now days the situation is totally changed and it is occupied by the new devices called Microcontroller. This microcontroller changed the embedded system design so simple and advanced that the embedded market has become one of the most sought after for not only entrepreneurs but for design engineers also **[5].**

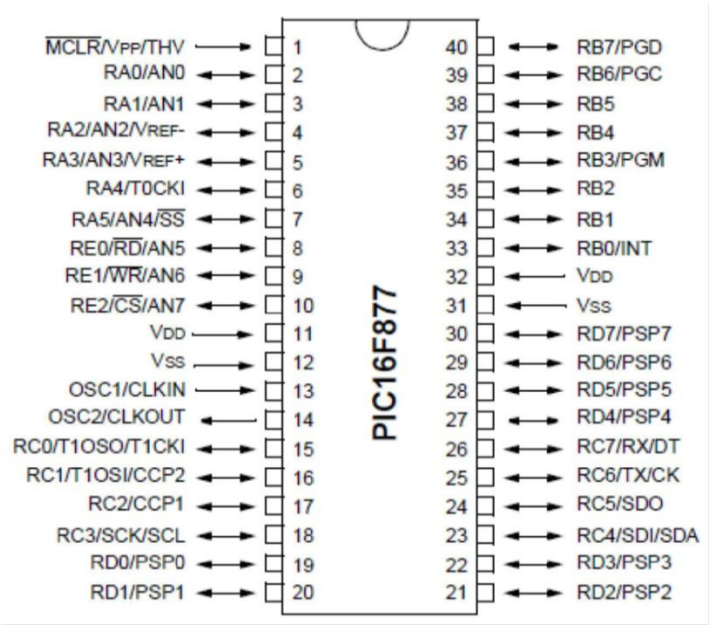

Figure 2: Pin lay out of PIC16F877A

Working Principle of Pic Microcontroller

The pic microcontroller has its own ADC port and it have input and output port. Based on this it receives and sends signal from peripheral devices. Then the output voltage from the bridge rectifier is give as input of the microcontroller then the microcontroller converts into digital and send signal to the transistor at that time current pass through the relay. The relay is energized, it can act as switch. A Microcontroller is used in the circuit for the continuous routine operation that is done for the working of the whole setup. The processor may obtain certain signals and operate as per the prescribed instructions. The speed of the processor depends on the oscillator circuit or crystals connected. The processor has some cache memory to store the recent events of the processor. The output signals of the controller is not efficient to drive any components hence we provide buffers and interfacing circuits. The microcontroller used is PIC16f877A, 40 pin microcontroller with 5 ports that can be used as both Input-output ports. The microcontrollers have inbuilt timers/counters, some memory.

2. Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and power circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers they repeated the signal coming in from one circuit and re-transmitted it on another circuit.

Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to

protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

The relay is given with a +12v DC volts from the output of bridge rectifier to the coil. A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts the moving part of the switch that is COM (common) terminal Figure 3.

The coil current can be ON or OFF so relays have two switch positions and most have double throw (changeover) switch contacts. Relays switch a second circuit which can be completely separate from the first.

The relay's switch connections are usually labeled COM, NC and NO.

- COM (Common), it is the moving part of the switch.
- NC (Normally closed); COM is connected to this when the relay coil is off.
- NO (Normally Open); COM is Connect to NO when the relay coil is energized [11].

Figure 3: relay circuit diagram

3. Overload Relays

Overload relays are designed to meet the special protective needs of motor control circuits.

- Allow harmless temporary overloads (such as motor starting) without disrupting the circuit.
- Will trip and open a circuit if current is high enough to cause motor damage over a period of time.
- It can be reset once the overload is removed.

4. Contactors

A contactor is an electrically controlled switch used for switching a power circuit, similar to a relay except with higher current ratings. A contactor is controlled by a circuit which has a much lower power level than the switched circuit. The contactor is actuated by the low power relay circuit. The contactor consists of electromagnetic coil which attracts the moving contacts by changing the contact positions. Contactor is of two types namely normally closed (NC) and normally open (NO).

Figure 4: contactor circuit diagram

Star Delta Starting

Star/Delta starters are the most common reduced voltage starters. They are used in an attempt to reduce the starting current applied to the motor during starting as a means of reducing the disturbances and interference on the electrical supply. The Star/Delta starter is constructed from three contactors. The single contactor used in a Direct on Line starters they are controlling winding currents only. The currents through the winding are $1\sqrt{3} = 0.58$ (58%) of the current in the line. This connection amounts to approximately 30% of the delta values. The starting current is reduced to one third of the direct starting current.

Working Principle of Star Delta Starter

There are three states of Star-Delta starters.

- Star Connected State.
- Open State and.
- Delta Connected State.

During starting time Main and Star Contactors remain closed and complete Circuit. In Star Connected State voltage applied is reduced to $1/\sqrt{3}$ of the Line Voltage across each winding.

As and when motor attains good rotational speed, say about 90% of full r.p.m. after few seconds, timer connected in starter disconnects Star Contactor while connects Delta Contactor. Between these two, Star connected and Delta connected states, circuit becomes open and motor neither remains in Star nor in Delta State. This is called open transition switching. In Delta connected state voltage applied to windings is equal to Line Voltage. Items Required to Make Star Delta Starter Three Contactors (One Main Contactor, One Star Contactor and One Delta Contactor), Over Load Relay (or OLR), Timer, Fuse, Start Push Button (NO), Stop Push Button(NC).Contactor relays are often used in control and regulating functions. They are used in large quantities for the indirect control of motors, valves, clutches and heating Equipment. In addition to the simplicity which they offer in project engineering, panel building, Commissioning and maintenance, the high level of safety which they afford is a major Factor in their favor there are two contactors that are close during run, often referred to as the main contractor and the delta contactor. The third contactor is the star contactor and that only carries star current while the motor is connected in star. The current in star is one third of the current in delta, so this contactor can be AC3 rated at one third of the motor rating. In operation, the Main Contactor (KM3) and the Star Contactor (KM1) are closed initially, and then after a period of time, the star contactor is opened, and then the delta contactor (KM2) is closed. The control of the contactors is by

the timer(K1T) built into the starter. The Star and Delta are electrically interlocked and preferably mechanically interlocked as well. Themotor has a spinning rotor and behaves like a generator deltaState. The Main and the Delta contactors are closed. The Starcontactor is open. The motor is connected to full line voltage and full power and torque are available.

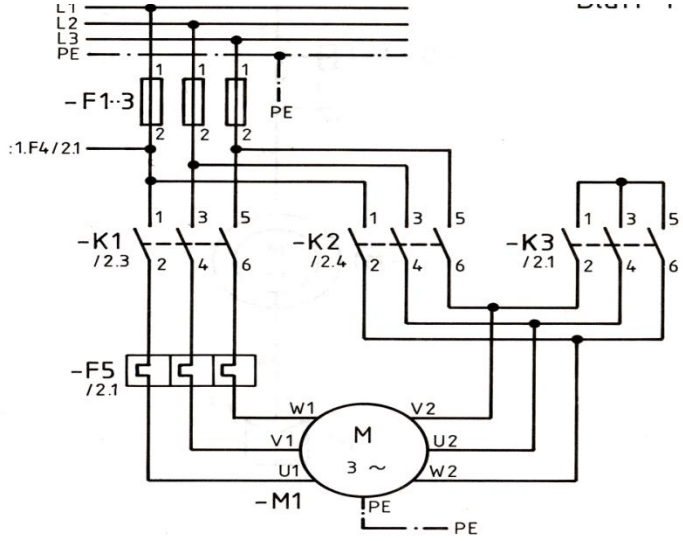

Figure 5: Star delta starting

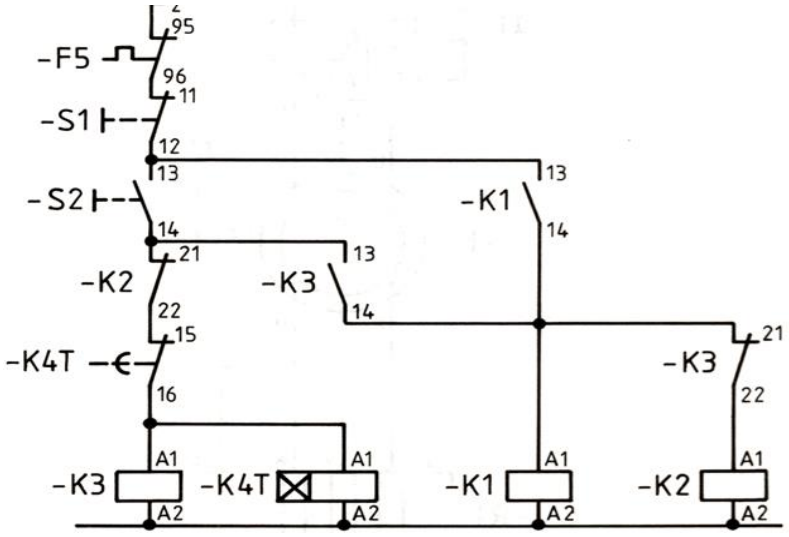

Figure 6: control circuit of star-delta starting with timer

5. Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors the transformer's coils. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic field through the secondary winding. This varying magnetic

field induces a varying electromotive force (EMF), or "voltage", in the secondary winding. This effect is called inductive coupling.

If a load is connected to the secondary, current will flow in the secondary winding, and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (Vs.) in proportion to the primary voltage (Vp) and is given by the ratio of the number of turns in the secondary (Ns) to the number of turns in the primary (Np) as follows:

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$

The transformer which used in this project is step down the voltage level from 220v to 12vAC and the current rating is 500mA. Then 12v AC voltage is given as the input for the bridge rectifier.

Step down transformer

Three center tapped step down transformer has been used for reducing of the phase voltage from 220v to 12v AC voltage. Step down transformer is used because the microcontroller can only read voltages up to 5 V. The step down voltage is further rectified through bridge rectifier [4].

When the input voltage of the step down transformer varies, the input of the microcontroller will also vary proportionally. There may be some normal fluctuation in the power system which can exist for few cycles, and tripping of motor for these fluctuations is not required. By taking this into account, the value of resistor across the capacitor is taken as half watt.

Higher value of the resistor will discharge the capacitor fast and response of the input value for the microcontroller will fast accordingly to the change of voltages in the input of transformer.

6. Voltage Regulator

A voltage regulator is designed to automatically maintain a constant voltage level. If the output voltage is too low (perhaps due to input voltage reducing or load current increasing), the regulation element is commanded, up to a point, to produce a higher output voltage by dropping less of the input voltage (for linear series regulators and buck switching regulators), or to draw input current for longer periods (boost-type switching regulators); if the output voltage is too high, the regulation element will normally be commanded to produce a lower voltage. However, many regulators have over-current protection, so that they will entirely stop sourcing current (or limit the current in some way) if the output current is too high, and some regulators may also shut down if the input voltage is outside a given range. This project uses IC7805 for the microcontroller and IC7812 for the relays. The 78xx (sometimes LM78xx) is a family of self-contained fixed linear voltage regulator integrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs with in the family, the xx is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5 volt output, while the 7812 produces 12 volts). The 78xx lines are positive voltage regulators: they produce a voltage that is positive relative to a common ground.

These devices support an input voltage anywhere from a couple of volts over the intended output voltage, up to a maximum of 35 or 40 volts, and typically provide 1 or 1.5 amperes of current.

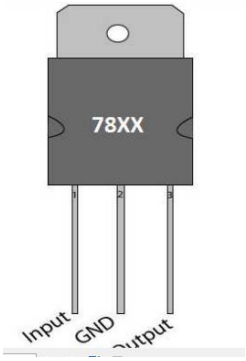

Figure 7: voltage regulator

7. Three Phase Induction Motor

Induction motor is one of the most important motors used in industrial applications.
Based on the construction of the rotor, a three phase induction motor can be categorized into two types:

1) Squirrel Cage Induction Motor.
2) Wound Rotor or Slip Ring Induction Motor.

The stator of both types of motors consists of a three phase balanced distributed winding with each phase mechanically separated in space by 120 degrees from the other two phase windings. This gives rise to a rotating magnetic field when current flows through the stator. In squirrel cage IM, the rotor consists of longitudinal conductor bars which are shorted at ends by circular conducting rings. Whereas, the wound rotor IM has a three phase balanced distributed winding even on the rotor side with as many number of poles as in the stator winding.

8. Bridge Rectifier

A diode bridge is an arrangement of four diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input.

The conversion of an alternating current (AC) input into direct current a (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two-wire AC input, resulting in lower cost and weight as compared to a rectifier with a 3-wire input from a transformer with a center-tapped secondary winding. The essential feature of a diode bridge is that the polarity of the output is the same regardless of the polarity at the input. The current is assumed to flow through electrical conductors from the positive to the negative pole. In actuality, free electrons in a conductor nearly always flow from the negative to the positive pole. In the vast majority of applications, however, the actual direction of current flow is irrelevant.

Diode

Ideally, a diode will conduct current in the direction of anode to cathode defined by the arrow in the symbol and act like an open circuit to any attempt to establish current in the opposite direction. The characteristics of an ideal diode are those of a switch that can conduct current in only one direction. In the description of the elements to follow, it is critical that the various letter symbols, voltage polarities, and current directions be defined. If the polarity of the applied voltage is consistent with that shown in figure 8(a), the portion of the characteristics to be considered in figure 8(b) is to the right of the vertical axis. If a reverse voltage is applied, the characteristics to the left are pertinent.

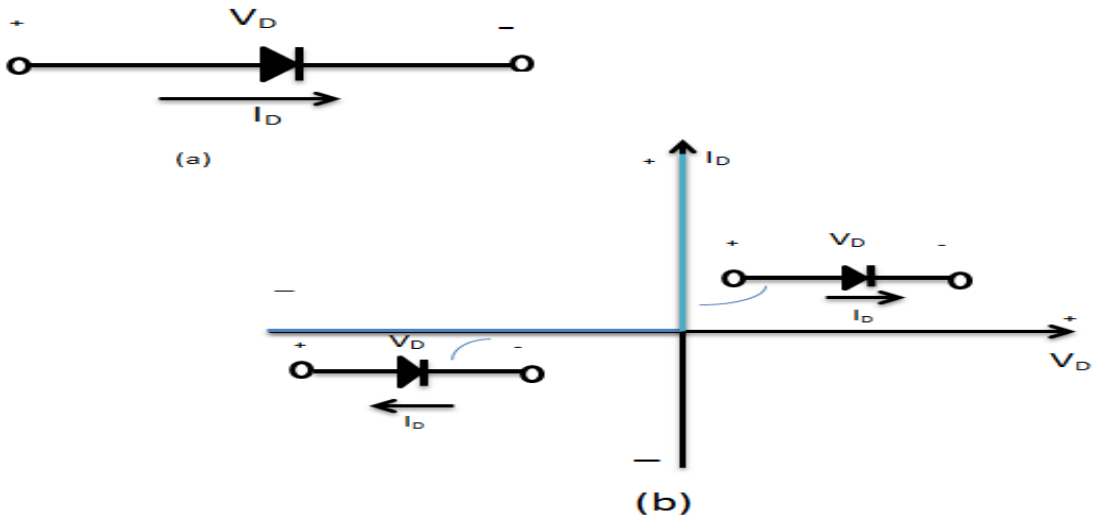

Figure 8: characteristics of diode

In general, it is relatively simple to determine whether a diode is in the region of conduction or non-conduction simply by noting the direction of the current ID established by an applied voltage. For conventional flow (opposite to that of electron flow), if the resultant diode current has the same direction as the arrowhead of the diode symbol, the diode is operating in the conducting region as depicted in figure 8.

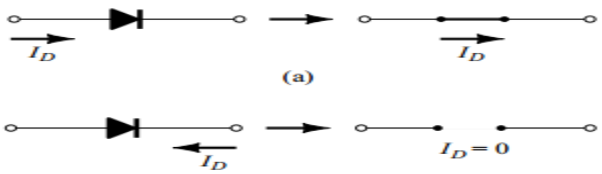

Figure 9: direction of diode

Figure 9(a) Conduction and (b) non-conduction states of the ideal diode as determined by the direction of conventional current established by the network.

Transistor

The main function of transistor in this project when the microcontroller send signal in to transistor the transistor get 5v then transistor connect to the ground and the current pass through the relay at that time the relay energized and closed the motor does get source, so the motor is running.

Transistor Construction

The transistor is a three-layer semiconductor device consisting of either two n- and one p type layers of material or two p- and one n-type layers of material. The former is called an npn transistor, while the latter is called a pnp transistor. Both are shown in figure 8. with the proper dc biasing. It is necessary to establish the proper region of operation for ac amplification. The emitter layer is heavily doped, the base lightly doped, and the collector only lightly doped. The outer layers have widths much greater than the sandwiched p- or n-type material. This lower doping level decreases the conductivity (increases the resistance) of this material by limiting the number of free

carriers. For the biasing shown in figure 8 the terminals have been indicated by the capital letters E for emitter, C for collector, and B for base. An appreciation for this choice of notation will develop when we discuss the basic operation of the transistor. The abbreviation BJT, from bipolar junction transistor, is often applied to this three terminal device.

The term bipolar reflects the fact that holes and electrons participate in the injection process into the oppositely polarized material. If only one carrier is employed (electron or hole), it is considered a unipolar device [6].

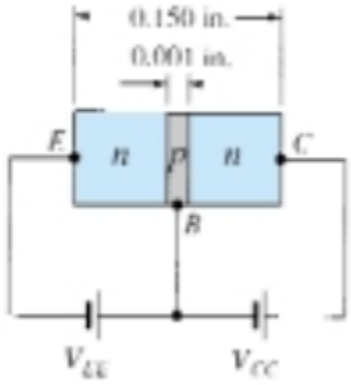

Figure 10: NPN Transistor

PHYSICAL COUPLING OF THE PROJECT

After we have test the equipment we have to configure the following hardware. The components used for the prototype are as such: the transformer, Power circuit i.e. relay and 12v power supply circuit for supply of power circuit. The complete embedded system connection is given below or figure 11.

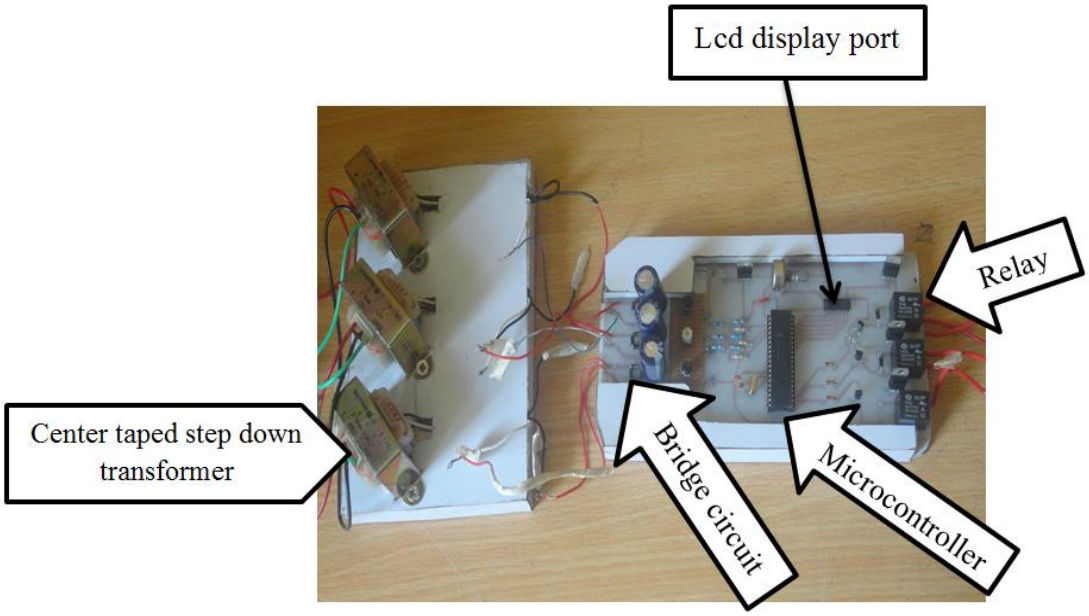

Figure 11: physical coupling of the project

CONCLUSION

In the project we have done protection of the three phase induction motor from starting current, single phasing, over rating voltage, under rating voltage and over load. First the motor is start by star-delta starting method to protect the motor from high starting current. Second the microcontroller checks the three phase input supply voltage lines, if one of the three lines is miss, the motor is face to single phasing problem so the microcontroller stop the motor. If one of the three lines is out of the range, the motor is face to over voltage or under voltage problem so the microcontroller stops the motor. Finally, if the load is over rated, then the motor faced to overload current, so the over load relay de-energized the contactor coil to abort the source then the motor is stop. Induction motor protection from unbalanced voltage and overload based on the program loaded to the microcontroller due to c language or MIKRO C. The manual operation is replaced by microcontroller automatic system is very efficiently and acceptable. The microcontroller would make a system easy to control and manage the motors.

RECOMMENDATION

Future scope the dissertation is to implement the inverter system on the large capacity three phase induction motors. In control circuit only the ratings of relay and potential transformer. has to be chosen accordingly while the power circuit has to be designed independently as per the rating of the motor. The inverter is also designed to make the three phase motor running under two phase supply without affecting motor operation.

In the future work instead of overload relay to replace current transformer then the current transformer easy to configure with the microcontroller and write its program in MIkRO C and loaded into microcontroller to protect three phase induction motor from over current.

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