CHAPTER ONE
INTRODUCTION

1.1 Background

For industrial and mining applications, 3-phase AC induction motors are the prime movers for the vast majority of machines. These motors can be operated either directly from the mains or from adjustable frequency drives. In modern industrialized countries, more than half the total electrical energy used in those countries is converted to mechanical energy through AC induction motors. The applications for these motors cover almost every stage of manufacturing and processing. Applications also extend to commercial buildings and the domestic environment. They are used to drive pumps, fans, compressors, mixers, agitators, mills, conveyors, crushers, machine tools, cranes, etc.

It is not surprising to find that this type of electric motor is so popular, when one considers its simplicity, reliability and low cost.

1.2 Problem Statement

Most large induction motors are started directly on line, but when very large motors are started that way, they cause a disturbance of voltage on the supply lines due to large starting current surges. The high starting current will produce severe a voltage drop and will affect the operation of other equipment. It is not desirable to start large motors direct on line (giving full voltage to the stator).

1.3 Objectives

The main aims of this project are:

- To control start current of induction motor through control buttons.
- The project is designed to control AC power to a load.
- Fast response.

1.4 Methodology

- To solve the problems induction motors have been studied generally.
- Used thyristor type TRIAC.
- And control in thyristor through a controller type microcontroller pic16 f73.
- And write it code by micro C language program.
- Design simulation of thyristor operated induction motor by simulink (MATLAB).
- Design circuit.

1.5 Layout

The thesis includes five chapters organized as follow:

Chapter one: demonstrate the problems, the objectives and methodology of the project.

Chapter two: presents the general theory of induction Motors, with focus on the chapter also the start control current of induction motor.

Chapter three: shows the components of the circuit.

Chapter four: describe the layout has been used in MATLAB/SIMULINK and show the result of the simulation.

Chapter five: contains the conclusion and recommendation.

CHAPTER TWO
GENERAL CONCEPTS

2.1 Introduction

The previous results showed that the direct starting method requires a large starting current which causes a disturbance to voltages on the supply lines. In other words, the large starting current produces a severe voltage drop which affects the operation of other equipment. Other than that, it is a quite good method because it provides a large starting torque in a short transient state, without the need of external equipment to help starting the motor. The previous features make the direct starting method the most common one to start a 3ph induction motor. The Soft starting method requires a reasonable starting current to generate a small starting torque at a long transient state, not to mention the need of external thyristor voltage regulator which means extra costs. On the other hand, it provides a smooth startup without any jerks along with a controlled flawless acceleration. These features give the Soft starting method a reliable accuracy with less current needed at the expense of stationary delay and external equipment charge.

2.2 Electric Motors

An electric motor is a device which converts electrical energy into kinetic energy. Most motors described in this guide spin on an axis, but there are also specialty motors that move linearly. All motors are either alternating current (AC) or direct current (DC).

All motors have two basic parts:

The Stator (stationary part).

The Rotor (rotating part).

The design and fabrication of these two components determines the classification and characteristics of the motor additional components (e.g. brushes, slip rings, bearings, fans, capacitors, centrifugal switches, etc.) may also be unique to a particular type of motor.

2.2.1 Operation

The motors described in this guide all operate on the principle of electromagnetism. Other motors do exist that operate on electrostatic and Piezoelectric principles, but they are less common. In electric motors, the magnitude of the force varies directly with the strength of the magnetic field and the amount of current flowing in the conductor.

In general, the rotor of an electric motor lies within a magnetic field created by the stator. The magnetic field induces a current within the rotor, and the resultant force caused by the magnetic fields in the stator and rotor (and thus torque) causes it to turn. In general there are many type of motors.

2.2.2 Types of motors

DC Motor (Shunt motor, series motor, compounded motor, permanent magnet DC (PMDC), separately excited motor).

AC Motor (Induction motor, synchronous motor).

Other motors (Stepper motor, brushless DC motor, hysteresis motor, reluctance motor, universal motor).

2.3 Induction motor

The three phase induction motors are also called as asynchronous motors, which are most commonly used type of motor in industrial applications. In particular, the squirrel-cage induction motor are widely used electric motor in home and industrial applications , because these machine are very economical, rugged and reliable. They are available in the ranges of the fractional horse power(FHP) to multi-megawatt capacity .fraction horse power motors are available in single-phase as well as poly-phase(three phase).The three phase machines are used most often in variable-speed drive where the torque requirement is motor.

An induction motor or synchronous motor is a type of alternating current motor where power is supplied to rotor by means of electromagnetic induction. An elect motor rotates because of magnetic force exerted between a stationary electromagnet called the stator and rotating electromagnet called the rotor. The current in stator side creates an electromagnetic field which interacts with the secondary to produce a resultant torque, transforming electrical energy into mechanical energy.

2.3.1 Construction

In this section, the construction details of induction motor are discussed. A three phase induction motor mainly consists of two parts, stator and rotor. Stator is the stationary part while the rotor is rotating part of the motor and they are separated by small air gap depending on the rating of the motor. The cross sectional view of induction motor and its various parts are shown in Figure (2.1)

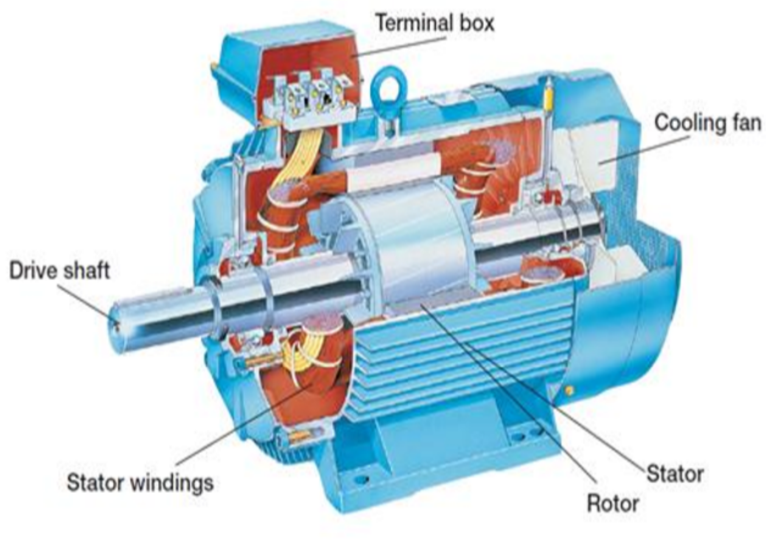


Figure 2.1: Squirrel cage three phase induction motor

- **Stator:** The stator is shown in Figure (2.2) which consists of a steel frame which encloses a hollow cylindrical core made up of thin laminations of silicon steel to reduce eddy current and hysteresis loss. A large number of uniform slots are cut on the inner periphery of the core. The stator conductors are placed in these slots which are insulated from one another and also from the slots. The windings are wound for a definite number of poles depending on the requirement of speed. It is wound for more number of pole, if speed required is less and vice versa. According to the relation

$$N_s = \frac{120f}{p} \qquad (2.1)$$

Where

Ns is the synchronous speed in RPM

F is the supply frequency

P is the number of poles

When a three phase supply is given to stator winding a magnetic field of constant magnitude and rotating at synchronous speed is produce. This rotating magnetic field is mainly responsible for producing the torque in the rotor, so that it can rotate at the rated speed.

Figure 2.2: Stator

❖ **Rotor:** The rotor is rotating part of induction motor and is mounted on the shaft of the motor to which any mechanical load can be connected. Based on the construction of the rotor, induction motors are broadly classified in two categories; squirrel cage motor and slip ring motor. The stator construction is the same in both motors.

Squirrel cage motors: Almost 90% of induction motors are squirrel cage motors. This is because the squirrel cage has a simple and rugged construction. Figure (2.3) show the squirrel cage type motor, it is consists of cylindrical laminated core with axially placed parallel slots for carrying rotor conductors. The rotor conductors are heavy bar of copper or aluminum. Each slot carries a copper, aluminum or alloy bar. If slot are semi closed, then these bars are inserted from the end. These rotor bars permanently short circuit at both ends by mean of the end ring, it is not possible to add any external resistance in series with the rotor circuit during starting. The slots are slightly skewed, which helps in two way i.e.

- It reduces noise due to magnetic hum and makes motor run quietly.
- It reduce locking tendency between rotor and stator.

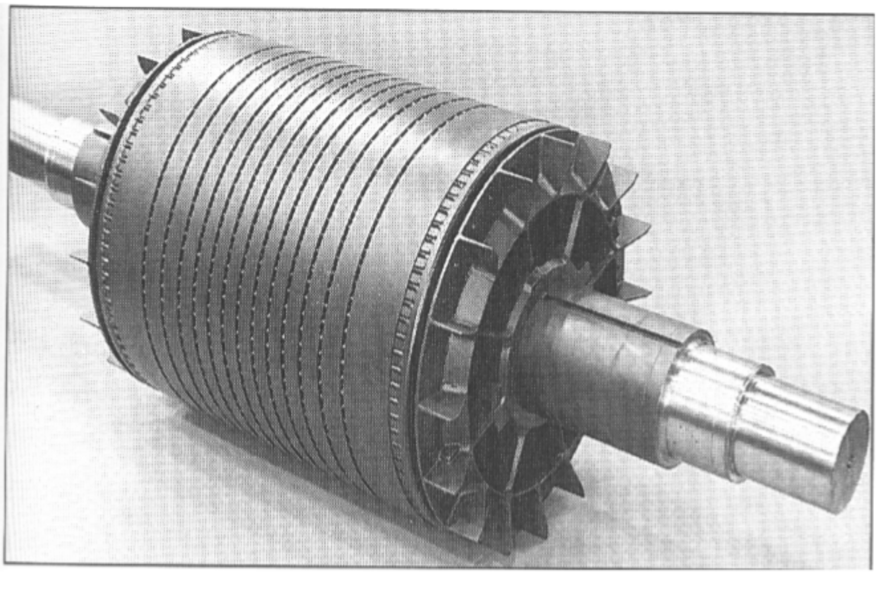


Figure 2.3: Squirrel Cage Type Rotor

Advantages of squirrel cage motor:

- It is simple in construction, rugged and can withstand rough handling.
- Maintenance cost is low.
- It is better efficiency and power factor.
- A simple star delta starter is sufficient to start the rotor.
- It is explosion proof as there are no slip ring and brushes.

Slip ring motors: In the slip ring motor, the windings on the rotor are terminated to three insulated slip ring mounted on the shaft with brushes resting on them. This allows an introduction of an external resistor to rotor winding. The external resistor can be used to boost the starting torque of the motor and change the speed torque characteristic. When running under normal condition, the slip rings are short circuit, using an external metal collar, which is pushed along the shaft to connect the rings. In normal condition, the slip ring motor functions like a squirrel cage motor.

2.3.2 Principle Operation of 3-Phase Induction Motor

When three phase supply is given to the three phase stator winding, a magnetic field of constant magnitude and rotating at synchronous speed Ns is produce. This rotating magnetic field sweeps across the rotor conductor and hence an electromagnetic force (EMF) is induction in rotor conductor. As the rotor conductors are short circuit on themselves the induce EMF step up a current in the rot r conductors in such a direction as to produce a torque, which rotates the rotor in the same direction as magnetic field so that relative speed decreases. The speed of gradually increases and tries to catch up with the speed of rotating magnetic field, but it fails to reach synchronous speed, because if it catches up with the rotor conductors, the speed of magnetic field, relative speed becomes zero and hence no EMF will be induce in the rotor conductor, the torque become zero . hence, rotor will not be able to catch up with the speed of magnetic field but rotates at a speed Nr which is slightly less than the synchronous speed.

2.3.3 Equivalent Circuit

The equivalent circuit is shown in Figure (2.4) from equivalent circuit diagram the various power expressions can be written as follow:

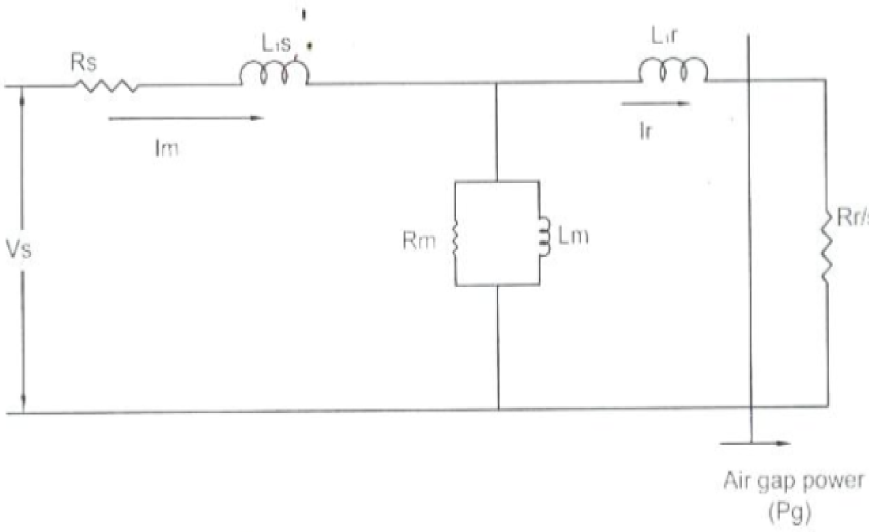


Figure 2.4: Per phase equivalent circuit of induction motor

$$P_{in} = 3V_s I_s \cos(\emptyset) \qquad (2.2)$$

$$P_{CUs} = 3I_s^2 R_s \qquad (2.3)$$

$$P_{iron} = \frac{3V_m^2}{R_m} \qquad (2.4)$$

$$P_g = 3\frac{R_r}{s}I_r^2 \qquad (2.5)$$

$$P_{Ir} = 3I_r^2 R_r \qquad (2.6)$$

$$P_o = P_g - P_{Ir} = \frac{3I_r^2 R_r(1-s)}{s} \qquad (2.7)$$

Since the output power is the product of developed torque T_e and speed ω_m, T_e can be expressed as

$$T_e = \frac{P_o}{\omega_m} = \frac{3}{\omega_m} I_r^2 R_r \left(\frac{1-s}{s}\right) = 3\left(\frac{P}{2}\right) I_r^2 \frac{R_r}{s\omega_e} \tag{2.8}$$

From the equivalent circuit, the approximate equivalent circuit can be obtained as shown in Figure (2.5), where the core loss resistor R_m has been dropped and the magnetizing inductance Lm has been shifted to the input. This approximation is easily justified for an integral horsepower machine.

where $(R_s + j\omega_e L_{Is}) \ll \omega_e L_m$

The performance prediction by the simplified circuit typically varies within five percent from the actual machine

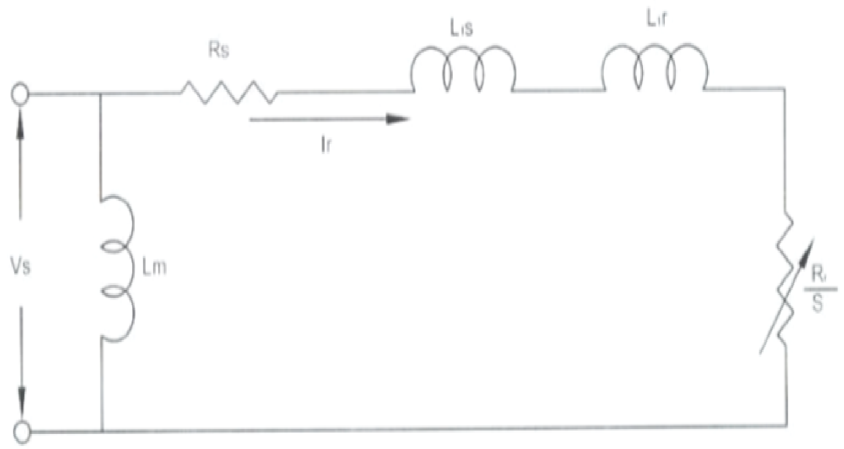


Figure (2.5) Approximate Per Phase Equivalent Circuit of IM

In Figure (2.5), the current I_r is figured out by:

$$I_r = \frac{V_s}{\sqrt{\left(R_s + \frac{R_r}{s}\right)^2 + \omega_e^2 (L_{ls} + L_{lr})^2}} \tag{2.9}$$

Substituting Equation (2.9) in (2.8) yields

$$T_e = 3\left(\frac{p}{2}\right) \frac{R_r}{s\omega_e} \frac{V_s^2}{\left(R_s + \frac{R_r}{s}\right)^2 + \omega_e^2 (L_{ls} + L_{lr})^2} \tag{2.10}$$

A further simplification of the equivalent circuit of figure (2.4) can be made by neglecting the stator parameter R_s and l_{Is}. This assumption is not unreasonable for an integral horsepower machine, particularly if the speed is typically above 10 percent. Then, the equation (2.10) can be simplified as

$$T_e = 3\left(\frac{P}{2}\right)\left(\frac{V_s}{\omega_e}\right)^2\left(\frac{\omega_{sl}R_r}{R_r^2+\omega_{sl}^2L_{lr}^2}\right) \tag{2.11}$$

Where $\omega_{sl} = s\omega_e$

The air gap flux can be given by

$$\Psi_m = \frac{V_s}{\omega_e} \tag{2.12}$$

In low slip region, equation (2.11) can be approximated as

$$T_e = 3\left(\frac{P}{2}\right)\frac{\Psi_m^2\omega_{sl}}{R_r} \tag{2.13}$$

Where $R_r^2 \gg \omega_{sl}^2L_{lr}^2$equation (2.13) is important because it indicated that at constant flux $\Psi_m$the torque T_e is proportional to slip frequency ω_{sl},or at constant slip frequency ω_{sl},torque T_e is proportional to Ψ_m^2.

2.3.4 Slip

The slip can be defined as the difference between the synchronous speed and actual speed of the machine. Based on this slip speed , the voltage induce in the rotor winding change, which in turn changes the rotor current and also the torque .A slip increase, the rotor current and torque also increase. The rotor moves in the same direction as that of the rotating magnetic field to reduce the induced current (Lenz's law).The slip can be expressed as given below:

$$s = \frac{N_s-N_r}{N_s} \tag{2.14}$$

$$s = \frac{\omega_e-\omega_r}{\omega_e} = \frac{\omega_{sl}}{\omega_e} \tag{2.15}$$

$$N_r=N_s\,(1\text{-}S) \tag{2.16}$$

$$N_s=120f/p \tag{2.17}$$

Where p represents the number of pole and f is stator frequency in Hz.

Therefore equation (2.16) become,

$$N_r=120f\,(1\text{-}S)/p \tag{2.18}$$

Thus, the speed of an induction motor depends on slip 'S', stator frequency 'f' and the number of pole 'p' for which the winding are wound.

The parameters of motor used in simulations are shown in table below:

Table2.1: Motor parameters

Parameters	Value
Rated voltage	415 V
Rated current	7.23 A
Stator resistance (R)	2 Ohm
Rotor resistance	1.78 Ohm
Rotor inductance	0.0085 H
Stator inductance	0.0085 H
Inertia	0.02
Rated speed	160 r.p.m
Frequency	50 Hz

2.4 Control

An automatic control system is a combination of components that act together in such a way that the overall system behaves automatically in a pre specified desired manner. A close examination of the various machines and apparatus that are manufactured today leads to the conclusion that they are partially or entirely automated, e.g., the refrigerator, the water heater, the clothes washing machine, the elevator, the TV remote control, the worldwide telephone communication systems, and the Internet. Industries are also partially or entirely automated, e.g., the food, paper, cement, and car industries. Examples from other areas of control applications abound: electrical power plants, reactors (nuclear and chemical), transportation systems (cars, airplanes, ships, helicopters, submarines, etc.), robots (for assembly, welding, etc.), wrap on systems (fire control systems, missiles, etc.), computers (printers, disk drives, magnetic tapes, etc.), farming (greenhouses, irrigation, etc.), and many others, such as control of position or velocity, temperature, voltage, pressure, fluid level, traffic, and office automation, computer-integrated manufacturing, and energy management for buildings. All these examples lead to the conclusion that automatic control is used in all facets of human technical activities and contributes to the advancement of modern technology. The distinct characteristic of automatic control is that it reduces, as much as possible, the human participation in all the aforementioned technical activities. This usually results in decreasing labor cost, which in turn allows the production of more goods and the construction of more works. Furthermore, automatic control reduces work hazards, while it contributes in reducing working hours, thus offering to work people a better quality of life (more free time to rest, develop hobbies, have fun, etc.) Control theory is essentially divided into two major:

As modern plants with many inputs and outputs become more and more complex, the description of a modern control system requires a large number of equations. Classical control theory, which deals only with single-input-single-output systems, becomes powerless for multiple-input-multiple-output systems. Since about 1960,because the availability of digital computers made possible time-domain analysis of complex systems, modern control theory, based on time-domain analysis and synthesis using state variables, has been developed to cope with the increased complexity of modern plants and the stringent requirements on accuracy, weight, and cost in military, space, and industrial applications. Recent applications of modern control theory include such non engineering systems as biological, biomedical, economic, and socioeconomic systems.

There are two main types of control system they are as follow:

Open loop control system.

Close loop control system.

2.4.1 Starting and speed control methods

Starting refers to speed, current, and torque variations in an induction motor when fed directly or indirectly from a rather constant voltage and frequency local power grid.

A “stiff” local power grid would mean rather constant voltage even with large starting currents in the induction motors with direct full-voltage starting (5.5 to 5.6 times rated current is expected at zero speed at steady state). Full-starting torque is produced in this case and starting over notable loads is possible.

A large design KVA in the local power grid, which means a large KVA power transformer, is required in this case. For starting under heavy loads, such a large design KVA power grid is mandatory.

On the other hand, for low load starting, less stiff local power grids are acceptable. Voltage decreases due to large starting currents will lead to a starting torque which decreases with voltage squared. As many local power grids are less stiff, for low starting loads, it means to reduce the starting currents, although in most situations even larger starting torque reduction is inherent for cage rotor induction machines.

For wound-rotor induction machines, additional hardware connected to the rotor brushes may provide even larger starting torque while starting currents are reduced. In what follows, various starting methods and their characteristics are presented. Speed control means speed variation with given constant or variable load torque. Speed control can be performed by either open loop (feed forward) or close loop (feedback) control. We will next introduce the main methods for speed control and the corresponding steady state characteristics.

✓ **Starting of cage-rotor induction motors**

Starting of cage-rotor induction motors may be performed by:

• Direct connection to power grid

• Low voltage auto-transformer

• Star-delta switch connection

• Additional resistance (reactance) in the stator

• Soft starting (through static various)

2.5 Thyristors

Thyritors are usually three-terminal devices with four layers of alternating p- and n-type material (i.e. three p-n junctions) in their main power handling section. In contrast to the linear relation that exists between load and control currents in a transistor, the thyristor is bitable. The control terminal of the thyristor, called the gate (G) electrode, may be connected to an integrated and complex structure as part of the device. The other two terminals, anode (A) and cathode (K) handle the large applied potentials (often of both polarities) and conduct the major current through the thyristor. The anode and cathode terminals are connected in series with the load to which power is to be controlled.

A thyristor used in some ac power circuits (50 or 60 Hz in commercial utilities or 400 Hz in aircraft) to control ac power flow can be made to optimize internal power loss at the expense of switching speed. These thyristors are called phase-control devices because they are generally turned from a forward-blocking into a forward-conducting state at some specified phase angle of the applied sinusoidal anode-cathode voltage waveform.

A second class of thyristors is used in association with dc sources or in converting ac power at one amplitude and frequency into ac power at another amplitude and frequency, and must generally switch on and off relatively quickly. A typical application for this second class of thyristors is that of converting a dc voltage or current into an ac voltage or current. A circuit that performs this operation is often called an inverter, and the associated thyristors used are referred to as inverter thyristors.

There are four major types of thyristors:

- Silicon controlled rectifier (SCR).
- Gate turn-off thyristor (GTO).
- MOS-controlled thyristor (MCT).
- Static induction thyristor (SITh).

2.5.1 Basic Structure and Operation

Figure shows a conceptual view of a typical thyristor with the three p-n junctions and the external electrodes labeled.

Also shown in the Figure (2.6) is the thyristor circuit symbol used in electrical schematics.

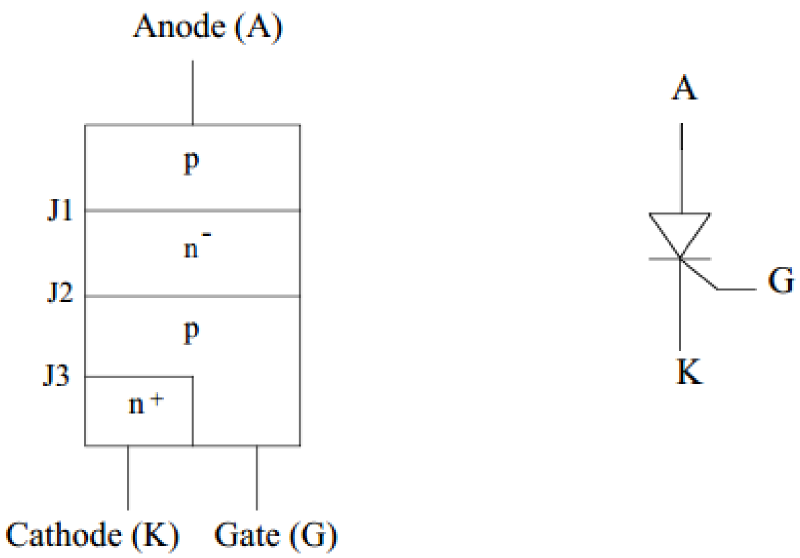


Figure 2.6: simple section of thyristor

A high-resistivity region, n-base, is present in all thyristors It is this region, the n-base and associated junction J2 of Figure (2.6), which must support the large applied forward voltages that occur when the switch is in its off- or forward-blocking state (non conducting). The n-base is typically doped with impurity phosphorus atoms at a concentration of 1014 cm^-3. The n-base can be 10s to 100s of mm thick to support large voltages. High-voltage thyristors are generally made by diffusing aluminum or gallium into both surfaces to obtain deep junctions with the n-base. The doping profile of the p-regions ranges from about 1015 to 1017 cm^-3. These regions can be up to 10s of mm thick. The cathode region (typically only a few mm thick) is formed by using phosphorus atoms at a doping density of 1017 to 1018 cm^-3. This switching behavior can also be explained in terms of the two-transistor analog shown in Figure (2.7)

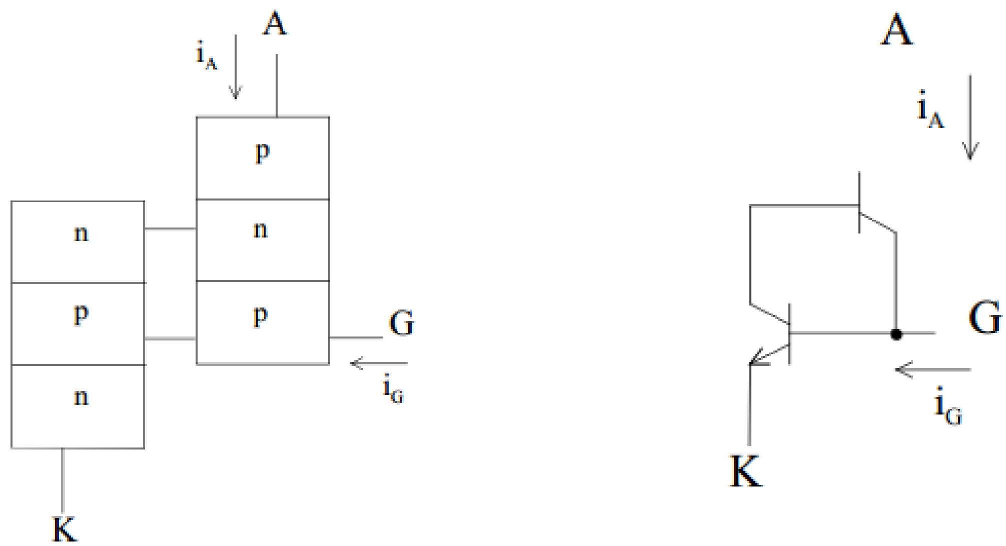


Figure 2.7: Two-transistor behavioral model of a thyristor.

2.5.2 Static Characteristics

Current-Voltage Curves for Thyristors A plot of the anode current (IA) as a function of anode cathode voltage (NAK) is shown in Fig. 3.3. The forward blocking mode is shown as the low-current portion of the graph (solid curve around operating point ‘‘1’’). With zero gates current and positive NAK the forward characteristic in the off- or blocking-state is determined by the center junction J2, which is reverse-biased. At operating point ‘‘1’’ very little current flows (ICO only) through the device. However, if the applied voltage exceeds the forward-blocking voltage, the thyristor switches to its on- or conducting-state (shown as operating point ‘‘2") because of carrier multiplication (M in Eq. 1). The effect of gate current is to lower the blocking voltage at which switching takes place. The thyristor moves rapidly along the negatively sloped portion of the curve until it reaches a stable operating point determined by the external circuit (point ‘‘2"). The portion of the graph indicating forward conduction shows the large values of IA that may be conducted at relatively low values of NAK, similar to a power diode.

As the thyristor moves from forward-blocking to forward conduction, the external circuit must allow sufficient anode current to flow to keep the device latched. The minimum anode current that will cause the device to remain in forward conduction as it switches from forward-blocking is called the

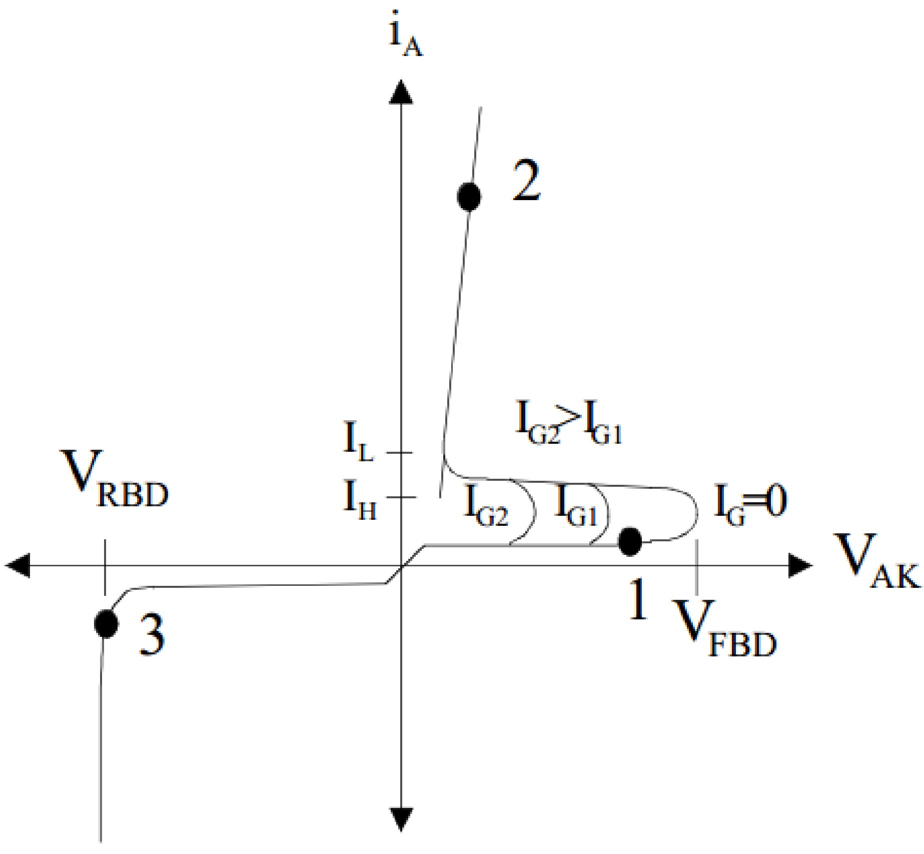


Figure2.8: Static characteristic of thyristors.

2.5.3 Dynamic Switching Characteristics

The time rate of rise of both anode current (di/dt) during turn-on and anode-cathode voltage (dn/dt) during turn-off is an important parameter to control for ensuring proper and reliable operation. All thyristors have maximum limits for (di/dt) and (dn/dt) that must not be exceeded. Devices capable of conducting large currents in the on-state are necessarily made with large-surface areas through which the current flows. During turn-on, localized areas (near the gate region) of a device begin to conduct current. The cross section illustrates how injected gate current flows to the nearest cathode region, causing this portion of the npn transistor to begin conducting. The pnp transistor then follows the npn into conduction.

2.6 Microcontroller

A microcontroller is a processor with memory and a whole lot of other components integrated on one chip. The first choice a designer has to make is the controller family – it defines the controller's architecture All controllers of a family contain the same processor core and hence are code-compatible, but they differ in the additional components like the number of timers or the amount of memory the basic internal designs of microcontrollers are pretty similar. Figure(2.9) shows the block.

Diagram of a typical microcontroller. All components are connected via an internal bus and are all integrated on one chip. The modules are connected to the outside world via I/O pins.

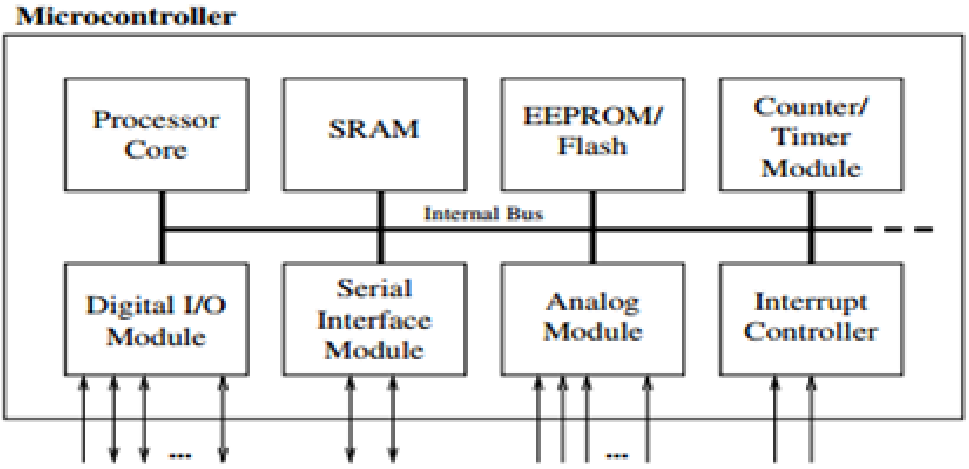


Figure 2.9: Block diagram of microcontroller

- **Processor Core:** The CPU of the controller. It contains the arithmetic logic unit, the control unit, and the registers (stack pointer, program counter, accumulator register, register file, . . .).
- **Memory:** The memory is sometimes split into program memory and data memory. In larger controllers, a DMA controller handles data transfers between peripheral components and the memory.
- **Interrupt Controller:** Interrupts are useful for interrupting the normal program flow in case of (important) external or internal events. In conjunction with sleep modes, they help to conserve power.
- **Timer/Counter:** Most controllers have at least one and more likely 2-3 Timer/Counters, which can be used to timestamp events, measure intervals, or count events.

Many controllers also contain PWM (pulse width modulation) outputs, which can be used to drive motors or for safe breaking (antilock brake system, ABS). Furthermore the PWM output can, in conjunction with an external filter, be used to realize a cheap digital/analog converter.

- **Digital I/O:** Parallel digital I/O ports are one of the main features of microcontrollers. The number of I/O pins varies from 3-4 to over 90, depending on the controller family and the controller type.
- **Analog I/O:** Apart from a few small controllers, most microcontrollers have integrated analog/digital converters, which differ in the number of channels (2-16) and their resolution (8-12 bits). The analog module also generally features an analog comparator. In some cases, the microcontroller in clouds digital/analog converters.
- **Interfaces:** Controllers generally have at least one serial interface which can be used to download the program and for communication with the development PC in general.

Since serial interfaces can also be used to communicate with external peripheral devices, most controllers offer several and varied interfaces like SPI and SCI.

Many microcontrollers also contain integrated bus controllers for the most common (field) busses. IIC and CAN controllers lead the field here. Larger microcontrollers may also contain PCI, USB, or Ethernet interfaces

- **Watchdog Timer:** Since safety-critical systems form a major application area of microcontrollers, it is important to guard against errors in the program and/or the hardware. The watchdog timer is used to reset the controller in case of software "crashes".
- **Debugging Unit:** Some controllers are equipped with additional hardware to allow remote debugging of the chip from the PC. So there is no need to download special debugging software, which has the distinct advantage that erroneous application code cannot overwrite the debugger.

Additional advantages of the integration are easy upgradability, lower power consumption, and higher reliability, which are also very important aspects in embedded systems. On the downside, using a microcontroller to solve a task in software that could also be solved with a hardware solution will not give you the same speed that the hardware solution could achieve. Hence, applications which require very short reaction times might still call for a hardware solution. Most applications, however, and in particular those that require some sort of human interaction (microwave, mobile phone), do not need such fast reaction times, so for these applications microcontrollers are a good choice.

2.6.1 Microcontroller Components

The microcontroller consisting of Memory, digital I/O, Analog I/O, Interrupts, Timer and counters, program counter (PC), stack pointer (SP), registers, data and address bus, data pointer, program status word (PWA), arithmetic and logic unit (ALU).The components as shown in figure(2.10).

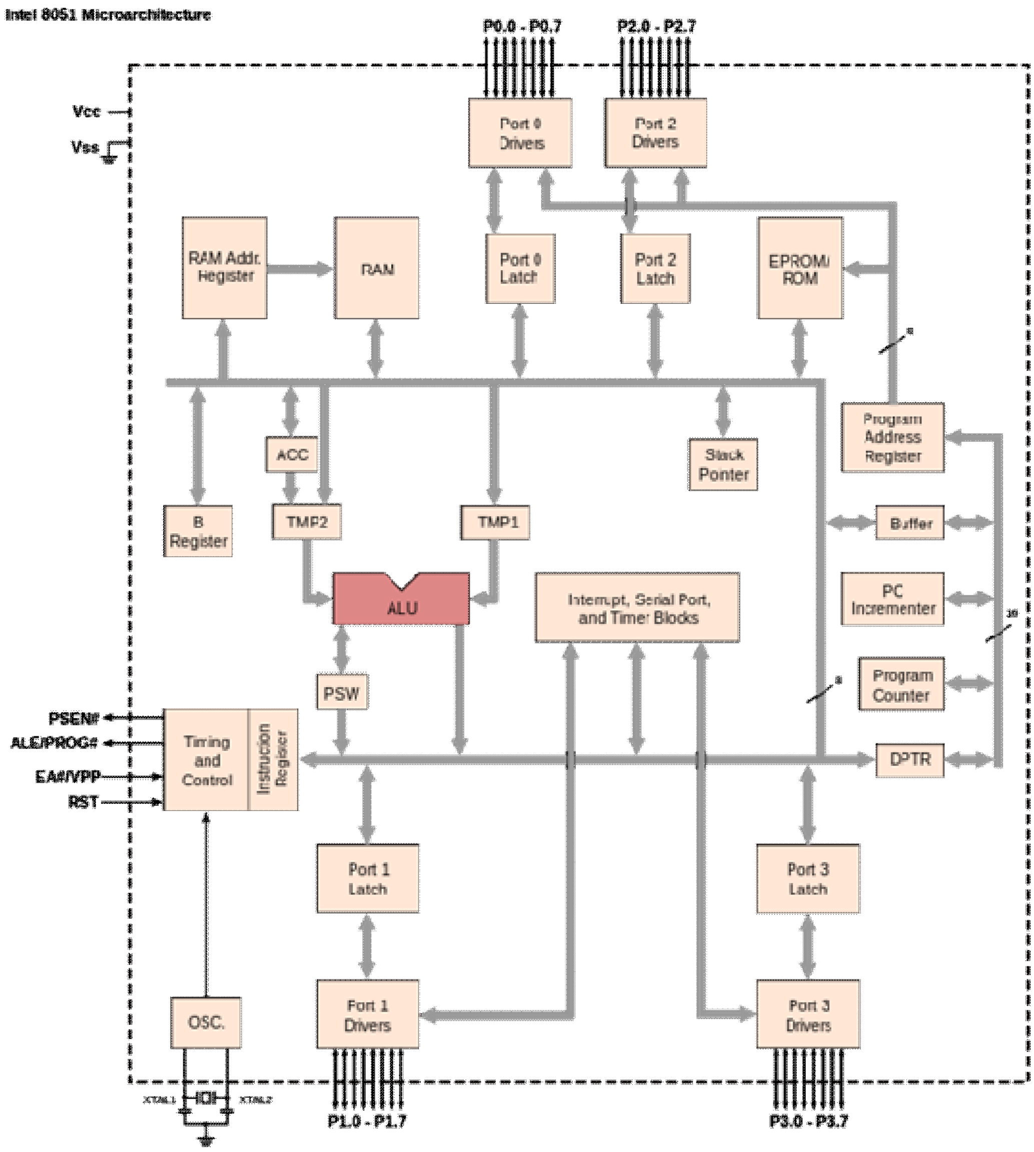


Figure 2.10: The components of microcontroller

CHAPTER THREE

DESIGN OF CIRCUIT

3.1 Introduction

An electronic component is any basic discrete device or physical entity in an electronic system used to affect electrons or their associated fields. Electronic components are mostly industrial products, available in a singular form and are not to be confused with electrical elements, which are conceptual abstractions representing idealized electronic components.

Electronic components have two or more electrical terminals (or leads) aside from antennas which may only have one terminal. These leads connect to create an electronic circuit with a particular function (for example an amplifier, radio receiver, or oscillator). Basic electronic components may be packaged discretely, as arrays or networks of like components, or integrated inside of packages such as semiconductor integrated circuits, hybrid integrated circuits, or thick film devices. The following list of electronic components focuses on the discrete version of these components, treating such packages as components in their own right.

- To solve the problem we use circuit this circuit consist of many components

The main blocks of this project are:

- Micro controller (16F73)
- Reset button
- Crystal oscillator
- Regulated power supply (RPS)
- Led indicator
- Zero crossing detector
- TRIAC

3.2 Microcontroller (16F73)

PIC16F73 is one of the latest products of Microchip. It features all the components which upgraded microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as: control of different processes in industry, machine control device, measurement of different values etc. Some of its main features (RISC architecture, Operating frequency 0-20 MHz Precision internal oscillator, Power supply voltage 2.0-5.5V, Power-Saving Sleep Mode).

The main reason is that Microchip Technology has continuously upgraded the device architecture and added needed peripherals to the microcontroller to suit customers' requirements.PIC16F73 already made with 368 bytes of Random Access Memory (RAM) inside it. Any temporary variable storage that we wrote in our program will be stored inside the RAM. Using this microcontroller you don't need to buy any external RAM.

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC16f originally developed by general instrument's microelectronics division. The name PIC initially referred to "Peripheral Interface Controller.

A PIC's instructions vary from about 35 instructions for the low-end PICs to over 80 instructions for the high-end PICs. The instruction set includes instructions to perform a variety of operations on registers directly, the accumulator and a literal constant or the accumulator and a register, as well as for conditional execution, and program branching A microcontroller can be considered a self-contained system with a processor, memory and peripherals and can be used as an embedded system.

Figure 3.1: Micro controller (pic16f73)

The 16f73 micro controller is powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller. The PIC 16F73 is a 28 pin IC in the physical structure with 3 ports like port A (6 pins), port B (8 pins), port C (8 pins) excluding the supply pins (4 pins). The parts of 16f73 at shown in figure (3.2). The pic16f73 is use for control the firing angle of the thyristors.

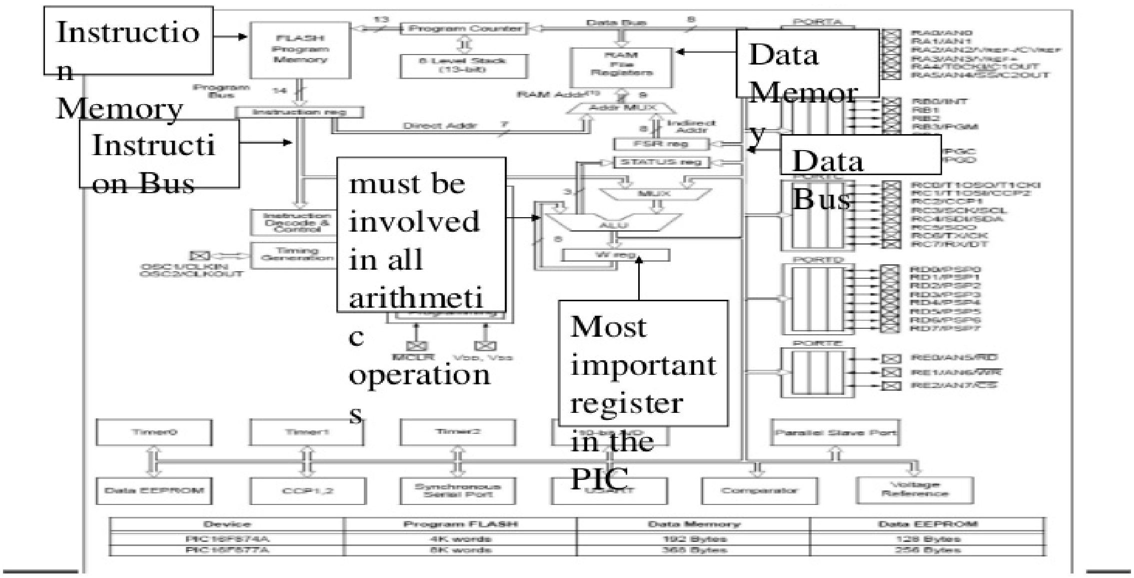


Figure 3.2: The parts of PIC 16f73

3.3 Regulated Power Supply

Power supply is a supply of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others PIC. The aim of this power supply is to convert 230V household supply to 5V DC. because PIC microcontrollers requires a 5V DC for its operation. The basic circuit diagram of a regulated power supply (DC O/P) with led connected as load is shown in Figure (3.3).

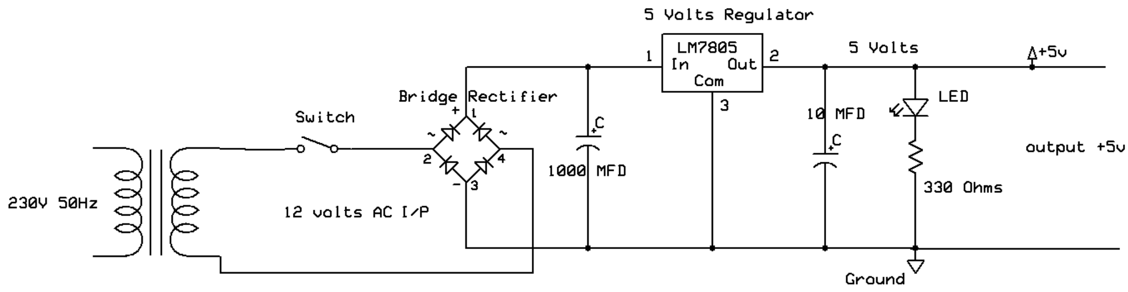


Figure 3.3: The basic circuit diagram of a regulated power supply

The components mainly used in the power supply is:

230V AC MAINS, Transformer (is a electromagnetic device which induces the voltage due to magnetic field , We are giving input 230v input voltage at primary side. The output of transformer is 9v (ac only), Bridge Rectifier (A rectifier is an electrical device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals.),filter (Electronic filters are electronic circuits, which perform signal-processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones.) Voltage Regulator(IC 7805) (The process of converting a varying voltage to a constant regulated voltage is called as regulation. For the process of regulation we use voltage regulators). Resistor (A resistor is a two-terminal electronic component that produces a voltage across its terminals that is proportional to the electric current passing through it in accordance with Ohm's law) ,LED(Light Emitting Diode**)** **(**A light-emitting diode (LED) is a semiconductor light source. LED’s are used as indicator lamps in many devices, and are increasingly used for lighting).

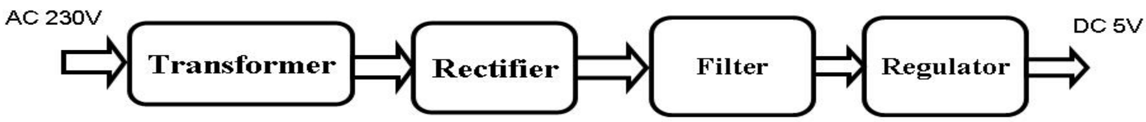


Figure 3.4: Block diagram of regulated power supply

3.4 Crystal Oscillator

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a precise frequency. This frequency is commonly used to keep track of time, as in quartz wristwatches, to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators, but other piezoelectric materials including polycrystalline ceramics are used in similar circuits.

Quartz crystals are manufactured for frequencies from a few tens of kilohertz to hundreds of megahertz. More than two billion crystals are manufactured annually. Most are used for consumer devices such as wristwatches, clocks, radios, computers, and cell phones. Quartz crystals are also found inside test and measurement equipment, such as counters, signal generators, and oscilloscopes. The quartz crystal oscillator circuit diagram can be represented as shown in Figure (3.5)

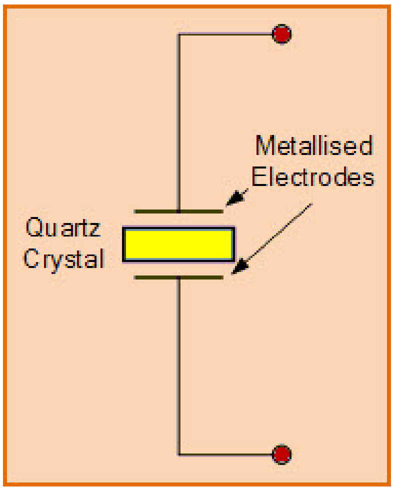


Figure 3.5: Electronic symbol for piezoelectric crystal resonator

An electronic circuit or electronic device that is used to generate periodically oscillating electronic signal is called as an electronic oscillator. The electronic signal produced by an oscillator is typically a sine wave or square wave. An electronic oscillator converts the direct current signal into an alternating current signal. The radio and television transmitters are broad casted using the signals generated by oscillators. The electronic beep sounds and video game sounds are generated by the oscillator signals. These oscillators generate signals using the principle of oscillation.

There are different types of oscillator electronic circuits such as Linear oscillators – Hartley oscillator, Phase-shift oscillator, Armstrong oscillator, Clapp oscillator, Colpitts oscillator, and so on, Relaxation oscillators – Royer oscillator, Ring oscillator, Multivibrator, and so on, and Voltage Controlled Oscillator (VCO).

In general, we know that, crystal oscillators are used in the microprocessors and microcontrollers for providing the clock signals. This crystal oscillator is used to generate clock pulses required for the synchronization of all the internal operations.

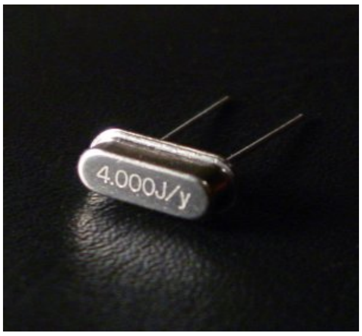


Figure 3.6: Crystal oscillator

3.5 Reset Button

Reset is used for putting the microcontroller into a 'known' condition. That practically means that microcontroller can behave rather inaccurately under certain undesirable conditions. In order to continue its proper functioning it has to be reset. A switch placed between the digital input and ground will short the digital input to ground when it is pressed. This means the voltage seen at the input will be high when the switch is open and low when the switch is closed.

Figure 3.7: Reset button

3.6 Light-Emitting-Diode (LED) Indicator

A light-emitting-diode (LED) is a semiconductor diode that emits light when an electric current is applied in the forward direction of the device, from the anode to the cathode. LEDs are widely used as indicator lights on electronic devices and increasingly in higher power applications such flashlights and area lighting. In the project, LED indicators are used to show the Microcontroller health status and indications for various operations. The LED s used in the project works with 2V, 10mA. The structure of the LED light is completely different than that of the light bulb. Amazingly, the LED has a simple and strong structure. The light-emitting semiconductor material is what determines the LED's color. The LED is based on the semiconductor diode. When a diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is usually small in area (less than 1 mm^2), and integrated optical components are used to shape its radiation pattern and assist in reflection. LED’s present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability. However, they are relatively expensive and require more precise current and heat management than traditional light sources. Current LED products for general lighting are more expensive to buy than fluorescent lamp sources of comparable output. They also enjoy use in applications as diverse as replacements for traditional light sources in automotive lighting (particularly indicators) and in traffic signals. The compact size of LED’s has allowed new text and video displays and sensors to be developed, while their high switching rates are useful in advanced communications technology. The electrical symbol and polarities of led are shown in Figure (3.8).

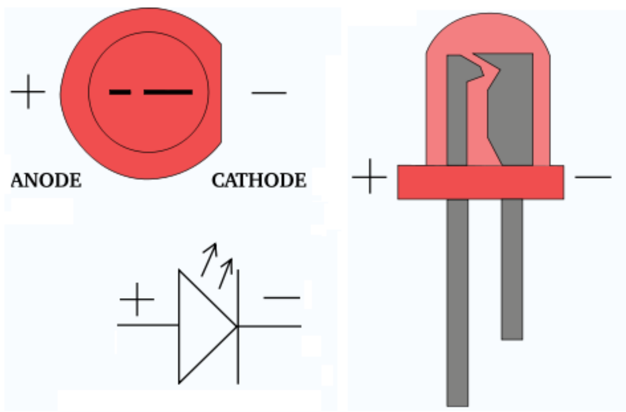
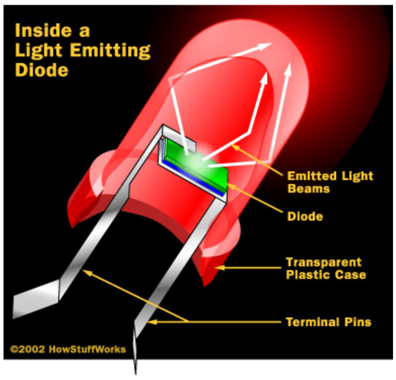
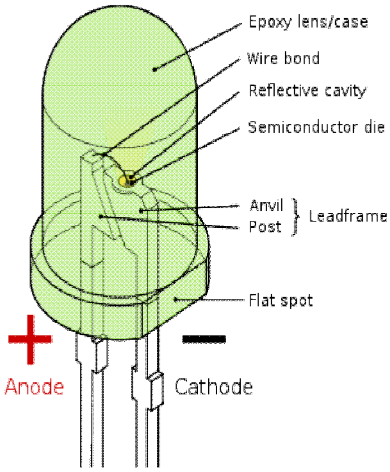


Figure 3.8: Electrical symbol & polarities of LED

Applications of LED fall into three major categories:

Visual signal application where the light goes more or less directly from the LED to the human eye, to convey a message or meaning, Illumination where LED light is reflected from object to give visual response of these objects. Generate light for measuring and interacting with processes that do not involve the human visual system.





Inside a LED **Parts of a LED**

Figure 3.9: Parts of a LED

3.7 Zero Crossing Detector

In alternating current, the zero-crossing is the instantaneous point at which there is no voltage present. In a sine wave or other simple waveform, this normally occurs twice during each cycle. The zero-crossing is important for systems which send digital data over AC circuits, such as modems, X10 home automation control systems, and Digital Command Control type systems for Lionel and other AC model trains. Counting zero-crossings is also a method used in speech processing to estimate the fundamental frequency of speech. In a system where an amplifier with digitally controlled gain is applied to an input signal, artifacts in the non-zero output signal occur when the gain of the amplifier is abruptly switched between its discrete gain settings. At audio frequencies, such as in modern consumer electronics like digital audio players, these effects are clearly audible, resulting in a 'zipping' sound when rapidly ramping the gain,or a soft 'click' when a single gain change is made. Artifacts are disconcerting and clearly not desirable. If changes are made only at zero-crossings of the input signal, then no matter how the amplifier gain setting changes, the output also remains at zero, thereby minimizing the change. (The instantaneous change in gain will still produce distortion, but will not produce a click.). If electrical power is to be switched, no electrical interference is generated if switched at an instant when there is no current—a zero crossing. Early light dimmers and similar devices generated interference; later versions were designed to switch at the zero crossing.

A zero-crossing is a point where the sign of a mathematical function changes (e.g. from positive to negative), represented by a crossing of the axis (zero value) in the graph of the function. It is acommonly used term in electronics, mathematics, sound, and image processing at shown in Figure (3.10).

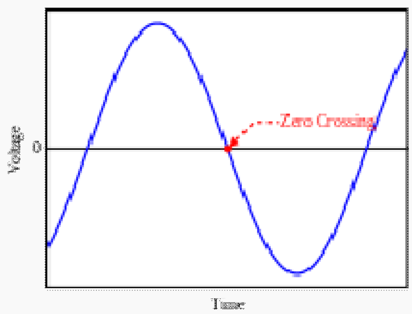


Figure 3.10: Zero-crossing in a waveform representing voltage vs. time

A zero crossing detector circuit is mainly used for protecting electronic devices from switch ON surges by ensuring that during power switch ON the mains phase always "enters' the circuit at its first zero crossing point. Zero crossing detector circuit is used to produce an o/p stage switch whenever the i/p crosses the reference i/p and it is connected to GND terminal. The o/p of the comparator can drive various outputs such as an LED indicator, a relay and a control gate. A ZCD can be used to measure the phase angle between two voltages. A sequence of pulses in the +ve and -ve cycles are acquired to measure the voltage between the time interval of the pulse of sine wave voltage and second sine wave. This interval of time is related to the phase difference between the two i/p sine wave voltages. The use of phase meter ranges from 0° to 360°.

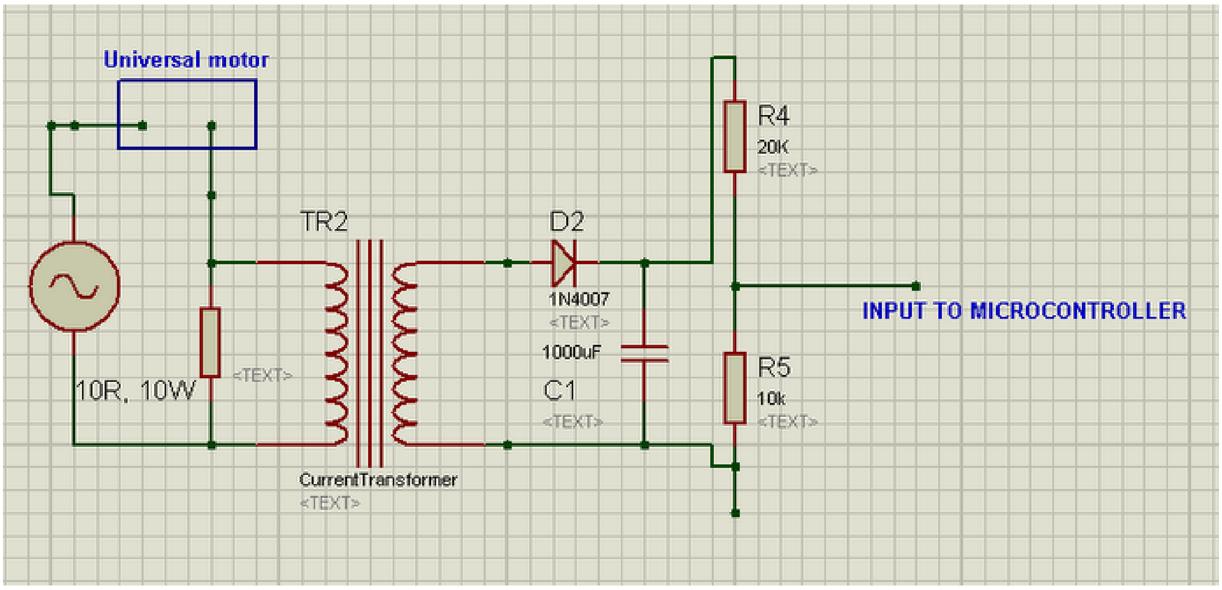
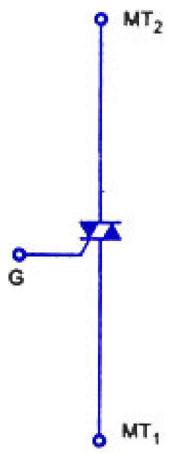


Figure 3.11: Diagram of ZCD for project

3.8 TRIAC

A TRIAC (“Triode for Alternating Current) is an electronic component approximately equivalent to two silicon-controlled rectifiers (SCRs/thyristors) joined in inverse parallel (paralleled but with the polarity reversed) and with their gates connected together. The formal name for a TRIAC is bidirectional triode thyristor. This results in a bidirectional electronic switch, which can conduct current in either direction when it is triggered (turned on) and thus doesn't have any polarity. It can be triggered by either a positive or a negative voltage being applied to its gate electrode (with respect to A1, otherwise known as MT1). Once triggered, the device continues to conduct until the current through it drops below a certain threshold value, the holding current, such as at the end of a half-cycle of alternating current (AC) mains power. This makes the TRIAC a very convenient switch for AC circuits, allowing the control of very large power flows with mille ampere-scale control currents. In addition, applying a trigger pulse at a controllable point in an AC cycle allows one to control the percentage of current that flows through the TRIAC to the load (phase control).

As mentioned above, triac is a three terminal, four layer bilateral semiconductor device. It incorporates two SCRs connected in inverse parallel with a com-mon gate terminal in a single chip device. The arrangement of the TRIAC is shown in Figure (3.12).



Schematic Symbol

Figure 3.12: Arrangement of the TRIAC

As seen, it has six doped regions. The gate terminal G makes ohmic contacts with both the N and P materials. This permits trigger pulse of either polarity to start conduction. Electrical equivalent circuit and schematic symbol are shown in Figure (3.14) and Figure (3.13) respectively.

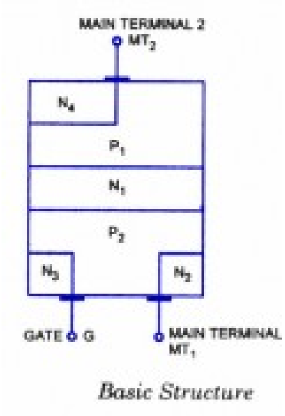


Figure 3.13

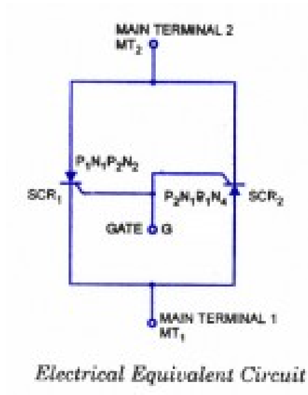


Figure 3.14

Since the triac is a bilateral device, the term "anode" and "cathode" has no meaning, and therefore, terminals are designated as main terminal 1. (MT1), main terminal 2 (MT2) and gate G. To avoid confusion, it has become common practice to specify all voltages and currents using MT1 as the reference.

Though the TRIAC can be turned on without any gate current provided the supply voltage becomes equal to the break over voltage of the triac but the normal way to turn on the TRIAC is by applying a proper gate current. As in case of SCR, here too, the larger the gate current, the smaller the supply voltage at which the TRIAC is turned on.

TRIAC can conduct current irrespective of the voltage polarity of terminals MT_1 and MT_2 with respect to each other and that of gate and terminal MT_2. Consequently

- Terminal MT_2 and gate are positive with respect to terminal MT_1(When terminal MT_2 is positive with respect to terminal MT_1 current flows through path P_1-N_1-P_2-N_2. The two junctions P_1-N_1 and P_2-N_2 are forward biased whereas junction N_1 P_2 is blocked. The TRIAC is now said to be positively biased.

A positive gate with respect to terminal MT_1 forward biases the junction P_2-N_2 and the breakdown occurs as in a normal SCR.)

- Terminal MT2 is positive but gate is negative with respect to terminal MT_1(Though the flow path of current remains the same as in mode 1 but now junction P_2-N_3 is forward biased and current carriers injected into P_2 turn on the TRIAC).
- Terminal MT_2 and gate are negative with respect to terminal MT_1(

When terminal MT_2 is negative with respect to terminal MT_1, the current flow path is P_2-N_1-P_1-N_4. The two junctions P_2-N_1 and $P_1 - N_4$ are forward biased whereas junction N_1-P_1 is blocked. The TRIAC is now said to be negatively biased.

A negative gate with respect to terminal MT_1 injects current carriers by forwards biasing junction P_2-$N_3$and thus initiates the conduction).

- Terminal MT2 is negative but gate is positive with respect to terminal MT1(Though the flow path of current remains the same as in mode 3 but now junction P_2-N_2 is forward biased, current carriers are injected and therefore, the TRIAC is turned on. Generally, trigger mode 4 should be avoided especially in circuits where high di/dt may occur. The sensitivity of triggering modes two and three is high and in case of marginal triggering capability negative gate pulses should be used. Though the triggering mode 1 is more sensitive compared to modes 2 and 3, it requires a positive gate trigger. However, for bidirectional control and uniform gate trigger modes 2 and 3 are preferred).

They are used TRIAC in control circuits. It is used in High power lamp switching. It is used in AC power control.

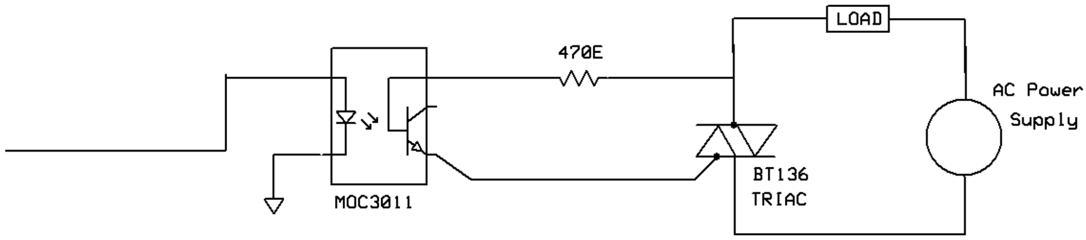


Figure 3.15: Circuit diagram of TRIAC

The parameter of thyristor used in the simulation is shown below.

Table3.1: parameter of thyristor

Parameters	Value
Resistance Ron	0.001 Ohms
Forward voltage Vf	0.8 V
Snubber resistance Rs	500 Ohms
Snubber capacitance Cs	250e-9 F

The figure diagram shown below explain the circuit component of the project :

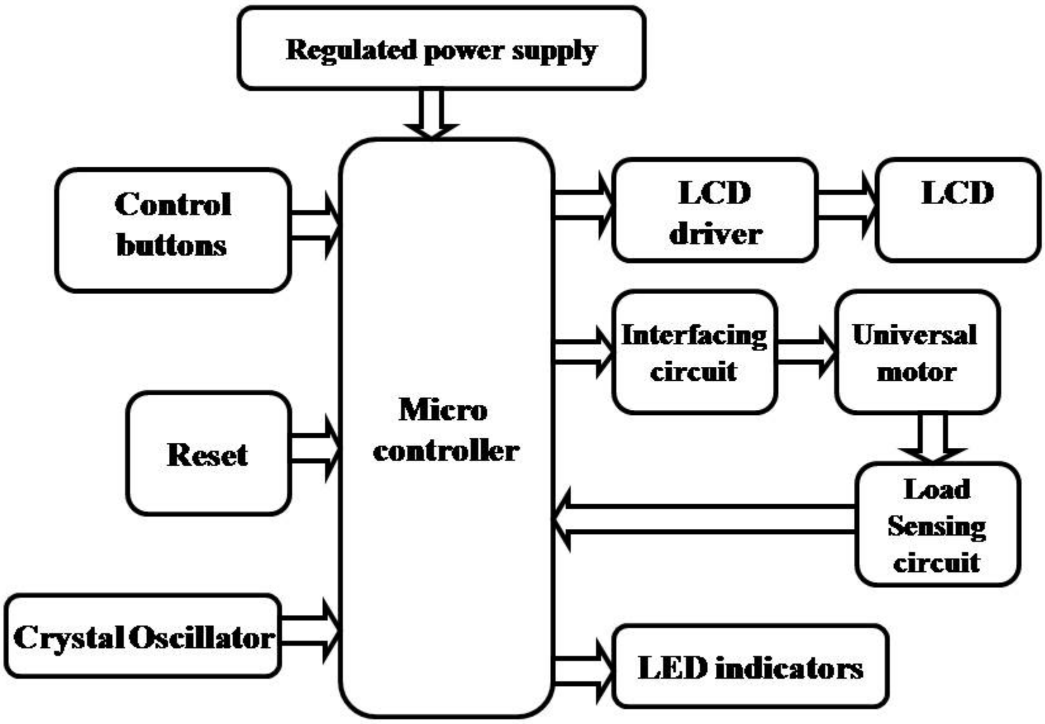


Figure 3.16: The block diagram of components

CHAPTER FOUR

IMPELEMENTATION OF CIRCUIT

4.1 Introduction

In order to Find a solution to the above problem it should be make simulation to the work of the project, until it is applied to the ground properly and sound was done by MATLAB SIMULINK program.

MATLAB is an interactive programming language that can be used in many ways, including data analysis and visualization, simulation and engineering problem solving. It may be used as an interactive tool or as a high level programming language. It provides an effective environment for both the beginner and for the professional engineer and scientist. SIMULINK is an extension to MATLAB that provides an iconographic programming environment for the solution of differential equations and other dynamic systems. In this study, a couple of methods of starting three-phase motors will be discussed and compared through curves of currents, torque, speed, efficiency and power factor. These methods are direct and soft starting. The discussion will be based on a MATLAB simulation of different loading cases of the induction motor

4.2 Simulation MATLAB

The figure show the Simulink modeling of thyristor controlled power for induction motor. This model contain 3-phase induction motor thus over all performance of thyristor controlled based system can be examine.

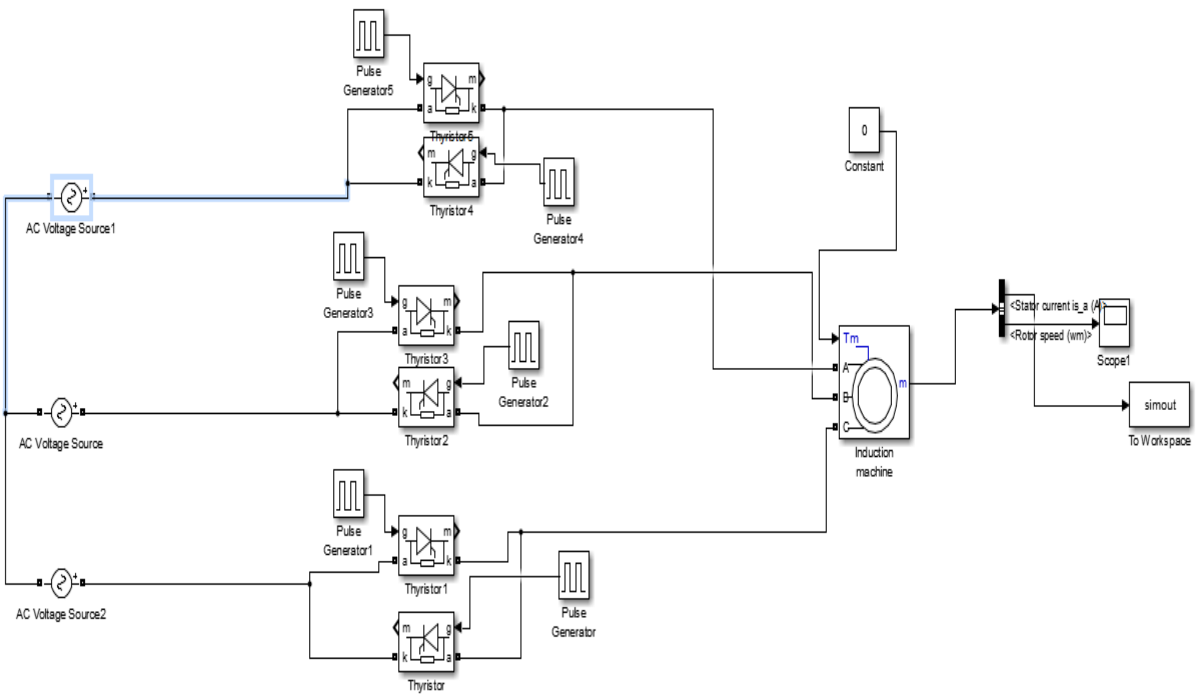


Figure 4.1: Simulink modeling

When the induction motor before connected to thyristor the stator current shown in figure (4.2)

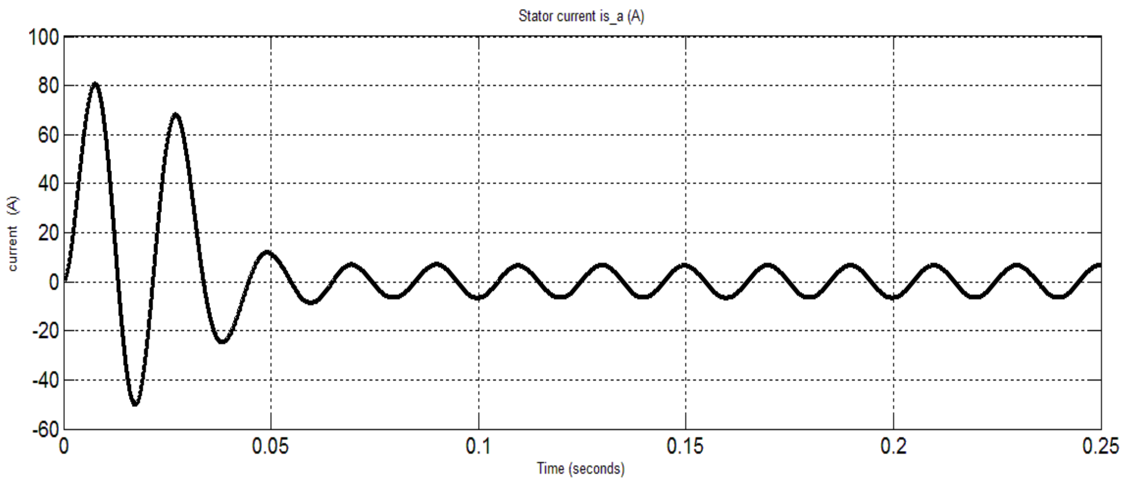


Figure 4.2: The stator current

When the induction motor before connected to thyristor the rotor speed shown in Figure (4.3)

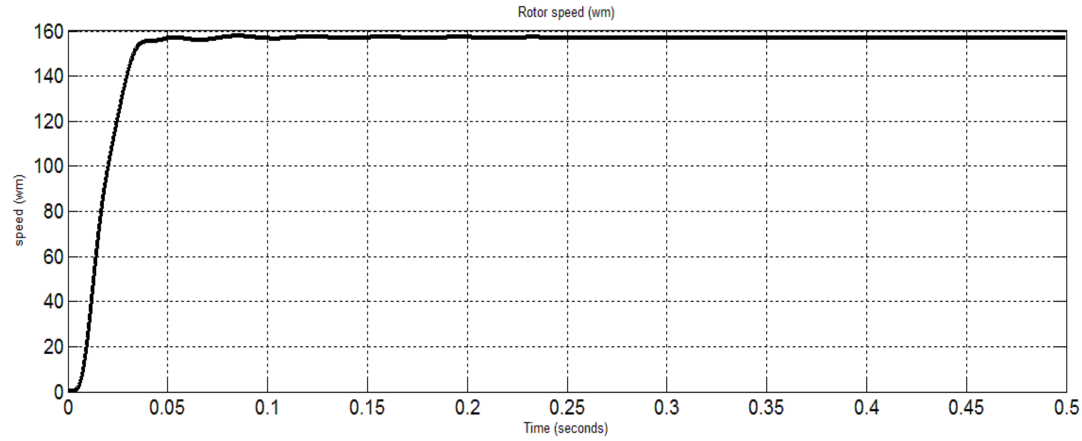


Figure 4.3:Rotor speed

When the induction motor after connected to thyristor the stator current shown in figure (4.4)

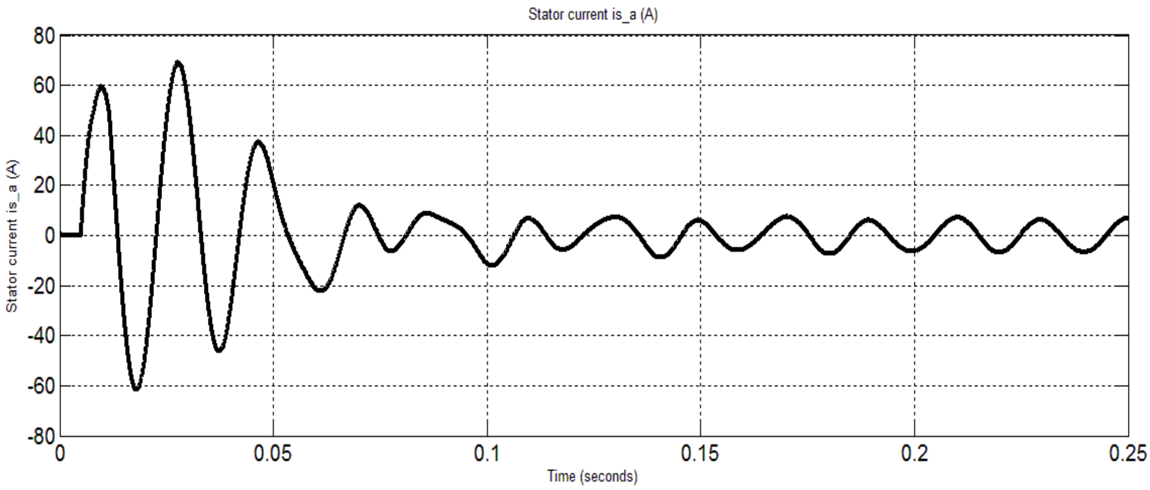


Figure 4.4: The stator current

When the induction motor after connected to thyristor the rotor speed shown in Figure (4.5)

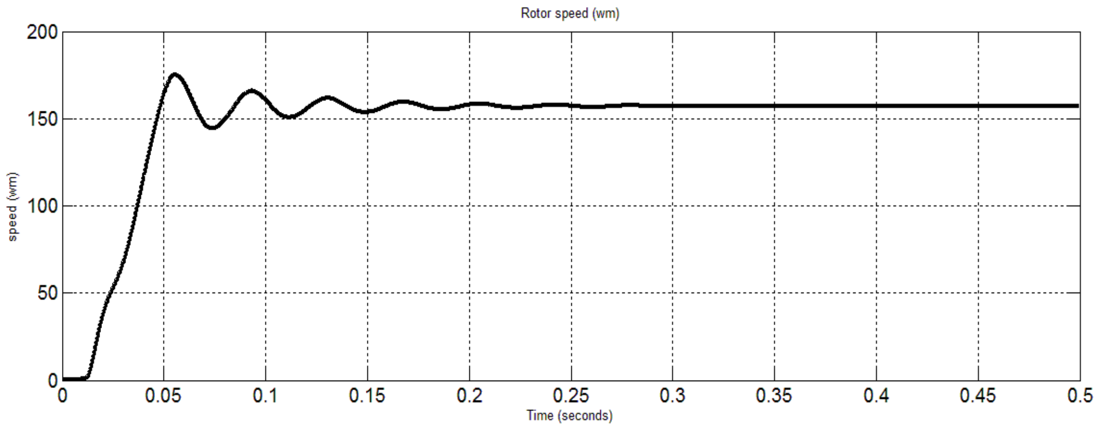


Figure 4.5: The rotor speed

4.3 Software program microcontroller

Proteus is software which accepts only hex files. Once the machine code is converted into hex code, that hex code has to be dumped into the microcontroller and this is done by the Proteus. Proteus is a programmer which itself contains a microcontroller in it other than the one which is to be programmed. This microcontroller has a program in it written in such a way that it accepts the hex file from the pic compiler and dumps this hex file into the microcontroller which is to be programmed. As the Proteus programmer requires power supply to be operated, this power supply is given from the power supply circuit designed and connected to the microcontroller in proteus. The program which is to be dumped in to the microcontroller is edited in proteus and is compiled and executed to check any errors and hence after the successful compilation of the program the program is dumped in to the microcontroller using a dumper. The micro controller programmed by c language attached in appendix.

4.4 Operation

The circuit has been implementation from the component mentioned in chapter three as shown in the figure below .by using 220v AC stepped down through transformer to 9v AC .the output of the transformer has been rectifier ,soften and regulated by using bridge rectifier ,capacitor and regulator respectively to fed the pic16f73 microcontroller. The microcontroller operation with oscillator 20MHz connected in pin 9,10. The output of micro controller from pin C4 to gate of thyristor throw driver MO 0311. The voltage controlled through two thyristors back to back connection that are connected to the lamp as shown in figure (4.6). The voltage of the lamp can be adjusted by modifying the pulses triggering angles, which are applied on the thyristors gates. The figure shown below explain the diagram of circuit

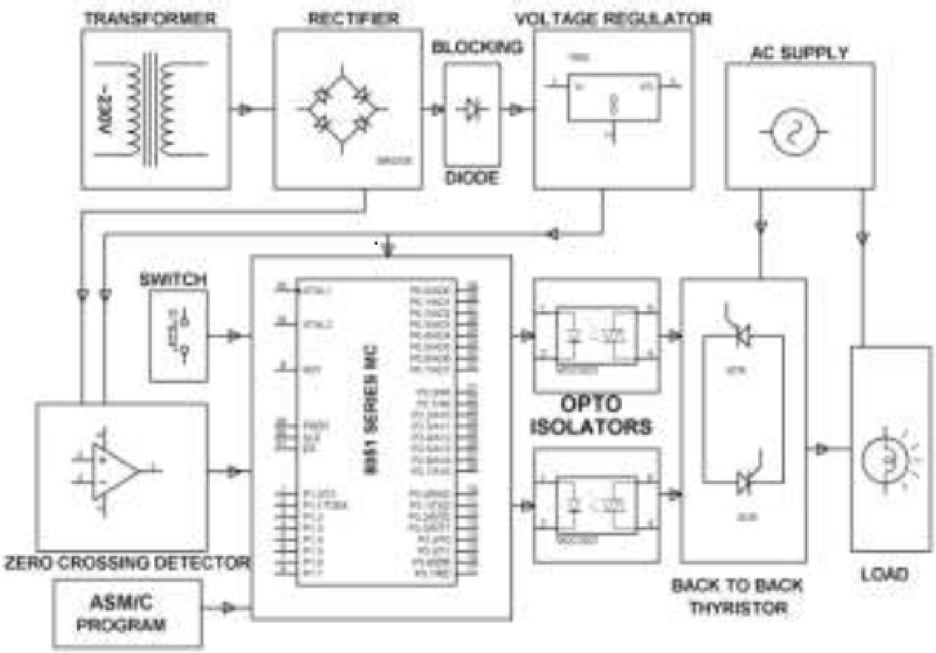


Figure 4.6:Diagram of the circuit

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

We had study the induction motors and controlled it via thyristor was the work of a theoretical study as described in chapter two . The project "The control start current of induction motor" was designed such that the system helps monitoring and controlling of induction motor current along. The project has been executed successfully and matched the results. Integrating features of all the hardware components used have been developed in it as described in chapter three . Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. Thus the project has been successfully designed and tested.

5.2 Recommendations

To achieve high performance of this system or to raise its efficiency many recommendations can be followed:

- ❖ Recommended to improve negative wave at thyristor.
- ❖ Recommended to stability speed after remove thyristor.

References

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[5]PIC Microcontroller Manual – Microchip

[6] Malcolm Barnes - Practical Variable Speed Drives and Power Electronics - First published 2003

[7] Katsuhiko Ogata, " modern control engineering University of Minnesota ".

Appendix A

The program of microcontroller

```
#include <16F73.h>  //Microcontroller used
#include <BT136.h>  //Triac file
#include <ZCD.h>  //Zero Crossing Detector

#use delay  (clock=20000000)

void main()
{
   output_high(PIN_C4);
   delay_ms(1000);
   output_low(PIN_C4);
   delay_ms(1000);
   output_high(PIN_C4);
   delay_ms(1000);
   output_low(PIN_C4);

   while(1)
   {
         if(input(PIN_C3)) //if button pressed
     {
       set_triac_speed(10); //10% voltage
                 output_high(PIN_C4);
       delay_ms(100);
       output_low(PIN_C4);
       delay_ms(2000);

       set_triac_speed(30); //30% voltage
                 output_high(PIN_C4);
       delay_ms(100);
       output_low(PIN_C4);
       delay_ms(2000);

                 set_triac_speed(50);  //50% voltage
                 output_high(PIN_C4);
       delay_ms(100);
       output_low(PIN_C4);
       delay_ms(2000);
```

```
            set_triac_speed(70);  //70% voltage
            output_high(PIN_C4);
    delay_ms(100);
    output_low(PIN_C4);
    delay_ms(2000);

            set_triac_speed(100);  //100% voltage
            output_high(PIN_C4);
    delay_ms(100);
    output_low(PIN_C4);
    while(1);
   }
  }
}
```