SPEED CONTROL OF SINGLE PHASE INDUCTION MOTOR BY THYRISTOR

Hiren M. Patel, Fagun N. Upadhyay, Sanny N Khalas
[1,2,3]*Lecturer, Electrical Department, VPMP Polytechnic-Gandhinagar, Gujarat, India*

ABSTRACT

The main aim of this project is to control the speed of an induction motor by applying varying voltages to the motor by using thyristor so that its speed can be controlled. The project uses zero crossing point of the waveform which is detected by a comparator whose output is then fed to the microcontroller. The microcontroller provides required delayed triggering control to a pair of SCRs through opto isolator interface. Finally the power is applied to the load through anti parallel SCRs in series. This project uses a microcontroller from 8051 family which is interfaced through a push-button switch for increasing or decreasing the AC power to the load. A lamp is used in place of an induction motor (not supplied) for demo purposes in the project whose varying intensity demonstrates the varying power to the motor. The varying power shall result in variation in the speed of the motor while the lamp is replaced by the motor. The project can be further enhanced by using 2 such units in any 3 phase supply for 3 phase induction motor.

INTRODUCTION

The characteristics of single phase induction motors are identical to 3-phase induction motors except that single phase induction motor has no inherent starting torque and some special arrangements have to be made for making itself starting. Though single phase induction motor is not self-starting we are using it because the 3-phase supply is not present at everywhere.

Especially in domestic purposes single phase induction motors are widely used. In many electrical appliances namely ceiling fan, refrigerator, washing machines etc. We are using this type of motor. The main reason behind using it is availability of single phase supply and one more is economical i.e., less costly in price. So speed control of induction motor is important.

In this project we are doing single phase induction motor speed control by using Thyristor. The complete control circuitry depends on only one parameter i.e., Voltage. We know that torque developed is proportional to square of the voltage. Thus the applied voltage to induction motor stator terminals is controlled by thyristor and its gate pulses.

When pulses to the gate are delayed then reduced voltage is applied to the induction motor stator terminals and thus as voltage and torques are proportional to each other, torque decrease and simultaneously speed of the motor gets reduced. The control circuitry consists of the following:

1. Triggering circuit
2. Thyristor circuit and
3. Power supply circuit.

The power supply circuit will provide DC supply 5v and 12v to the electronic devices which require the biasing voltage.

The triggering circuit will generate the pulses and are given to thyristor as gate pulses for triggering purpose.

And finally thyristor circuit acts as intermediate part between supply and induction motor. Therefore applied voltage from the supply to induction motor and thereby speeds are controlled.

I.M PRINCIPLE OF OPERATION

An induction or asynchronous motor is a type of AC motor where power is supplied to the rotor by means of electromagnetic induction, rather than a commutator or slip rings as in other types of motor. These motors are widely used in industrial drives, particularly poly phase induction motors, because they are rugged and have no brushes. Single-phase versions are used in small appliances. Their speed is determined by the frequency of the supply current, so they are most widely used in constant-speed applications, although variable speed versions, using variable frequency drives are becoming more common. The most common type is the squirrel cage motor, and this term is sometimes used for induction motors generally.

In both induction and synchronous motors, the stator is powered with alternating current (poly phase current in large machines) and designed to create a rotating magnetic field which rotates in time with the AC oscillations. In a synchronous motor, the rotor turns at the same rate as the stator field. By contrast, in an induction motor the rotor rotates at a slower speed than the stator field. Therefore the magnetic field through the rotor is changing (rotating). The rotor has windings in the form of closed loops of wire. The rotating magnetic flux induces currents in the windings of the rotor as in a transformer. These currents in turn create magnetic fields in the rotor, that interact with (push against) the stator field. Due to Lenz's law, the direction of the magnetic field created will be such as to oppose the change in current through the windings. The cause of induced current in the rotor is the rotating stator magnetic field, so to oppose this the rotor will start to rotate in the direction of the rotating stator magnetic field to make the relative speed between rotor and rotating stator magnetic field zero.

For these currents to be induced, the speed of the physical rotor must be lower than that of the stator's rotating magnetic field, or the magnetic field would not be moving relative to the rotor conductors and no currents would be induced. As the speed of the rotor drops below synchronous speed, the rotation rate of the magnetic field in the rotor increases, inducing more current in the windings and creating more torque. The ratio between the rotation rate of the magnetic field as seen by the rotor (slip speed) and the rotation rate of the stator's rotating field is called "*slip*". Under load, the speed drops and the slip increases enough to create sufficient torque to turn the load. For this reason, induction motors are sometimes referred to as asynchronous motors. An induction motor can be used as induction generator, or it can be unrolled to form the linear induction motor which can directly generate linear motion.

TYPES OF INDUCTION MOTORS

Generally, induction motors are categorized based on the number of stator windings. They are:

- **Single-phase induction motor**
- **Three-phase induction motor**

Single-Phase Induction Motor:

There are probably more single-phase AC induction motors in use today than the total of all the other types put together. It is logical that the least expensive, lowest maintenance type motor should be used most often. The single-phase AC induction motor best fits this description.

As the name suggests, this type of motor has only one stator winding (main winding) and operates with a single-phase power supply. In all single-phase induction motors, the rotor is the squirrel cage type.

Three-Phase AC Induction Motor:

Three-phase AC induction motors are widely used in industrial and commercial applications. They are classified either as squirrel cage or wound-rotor motors. These motors are self-starting and use no capacitor, start winding, centrifugal switch or other starting device. They produce medium to high degrees of starting torque. The power capabilities and efficiency in these motors range from medium to high compared to their single-phase counterparts. Popular applications include grinders, lathes, drill presses, pumps, compressors, conveyors, also printing equipment, farm equipment, electronic cooling and other mechanical duty applications.

Single phase induction starting methods

The single-phase IM has no starting torque, but has resultant torque, when it rotates at any other speed, except synchronous speed. It is also known that, in a balanced two-phase IM having two windings, each having equal number of turns and placed at a space angle of (electrical), and are fed from a balanced two-phase supply, with two voltages equal in magnitude, at an angle of , the rotating magnetic fields are produced, as in a three-phase IM. The torque-speed characteristic is same as that of a three-phase one, having both starting and also running torque as shown earlier. So, in a single-phase IM, if an auxiliary winding is introduced in the stator, in addition to the main winding, but placed at a space angle of (electrical), starting torque is produced. The currents in the two (main and auxiliary) stator windings also must be at an angle of , to produce maximum starting torque, as shown in a balanced two-phase stator. Thus, rotating magnetic field is produced in such motor, giving rise to starting torque. The various starting methods used in a single-phase IM are described here.

Split Phase Motor

The split-phase motor is also known as an induction start induction run motor. It has two windings: a start and a main winding. The start winding is made with smaller gauge wire and fewer turns, relative to the main winding to create more resistance, thus putting the start winding's field at a different angle than that of the main winding which causes the motor to start rotating. The main winding, which is of a heavier wire, keeps the motor running the rest of the time. The starting torque is low, typically 100% to 175% of the rated torque. The motor draws high starting current, approximately 700% to 1,000% of the rated current. The maximum generated torque ranges from 250% to 350% of the rated torque.

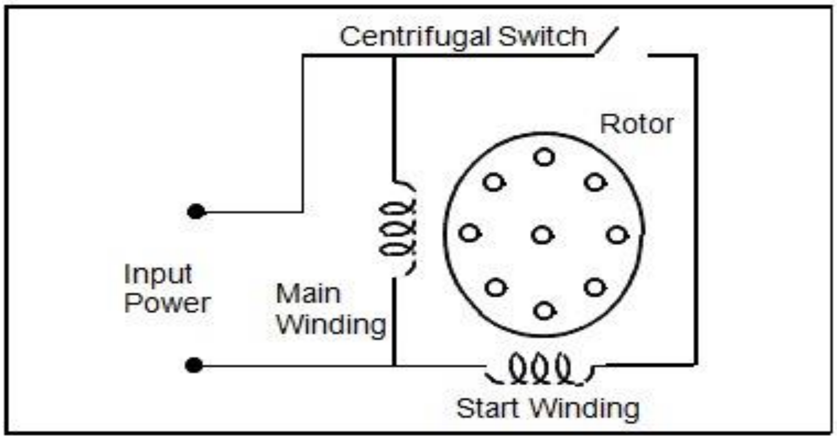


Fig 3.1 Typical Split-Phase AC Induction Motor

Good applications for split-phase motors include small grinders, small fans and blowers and other low starting torque applications with power needs from 1/20 to 1/3 hp. Avoid using this type of motor in any applications requiring high on/off cycle rates or high torque.

Capacitor Start Motor

This is a modified split-phase motor with a capacitor in series with the start winding to provide a start "boost." Like the split-phase motor, the capacitor start motor also has a centrifugal switch which disconnects the start winding and the capacitor when the motor reaches about 75% of the rated speed. Since the capacitor is in series with the start circuit, it creates more starting torque, typically 200% to 400% of the rated torque. And the starting current, usually 450% to 575% of the rated current, is much lower than the split-phase due to the larger wire in the start circuit. A modified version of the capacitor start motor is the resistance start motor. In this motor type, the starting capacitor is replaced by a resistor. The resistance start motor is used in applications where the starting torque requirement is less than that provided by the capacitor start motor. Apart from the cost, this motor does not offer any major advantage over the capacitor start motor.

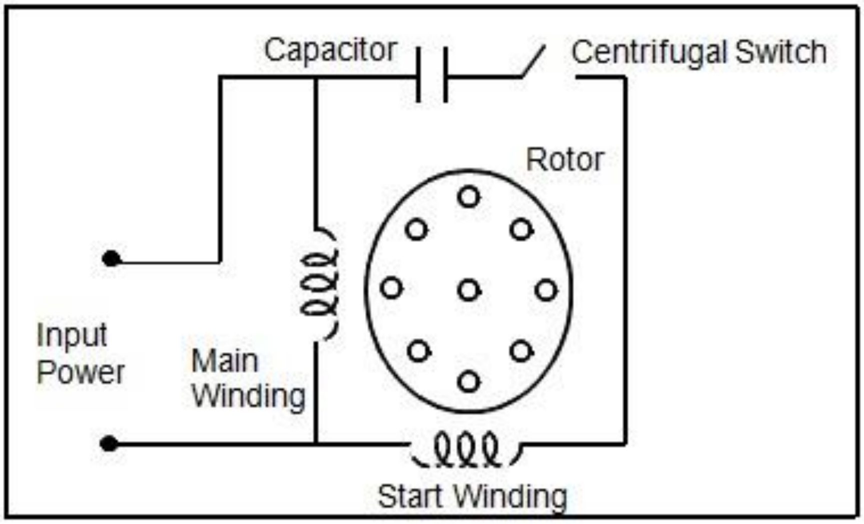


Fig 3.2 Typical Capacitor Start Induction Motor

They are used in a wide range of belt-drive applications like small conveyors,large blowers and pumps, as well as many direct-drive or geared applications.

It is able to handle applications too demanding for any other kind of single phase motor. These include wood-working machinery, air compressors, high-pressure water pumps, vacuum pumps and other high torque applications requiring 1 to 10 hp.

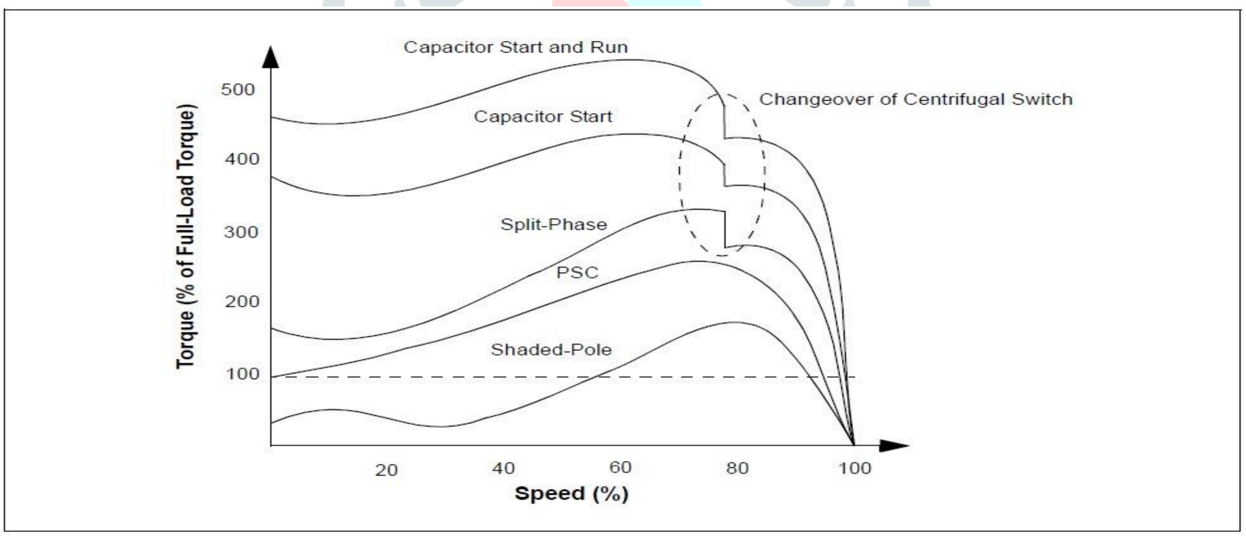


Fig 3.3 Torque-Speed Curves of Different Types of Single-Phase Induction Motors

SPEED CONTROL METHOD OF SINGLE PHASE I.M

For the speed control of single phase induction motor we have only one method called as "STATOR VOLTAGE CONTROL OF SINGLE PHASE INDUCTION MOTOR." In speed control by stator voltage control, the stator voltage is reduced from base value of rated speed to a lower value. As torque is proportional to voltage square, the torque speed characteristics goes down proportional to voltage square. With shifting of torque characteristics the operating point will also move to give a reduce motor speed. For a well-designed machine with low value of slip the reduction in speed with reduced voltage is very small. Therefore if a large drop in speed I required with reduction in stator voltage, the motor is specially designed with high full load slip.

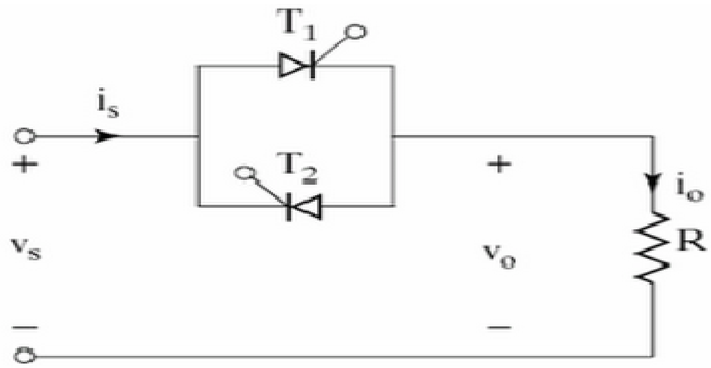


Fig 4.1 AC voltage controller

Using thyristor the control of stator voltage can be obtained by using AC voltage controller where reverse-parallel connected thyristors are used in each phase between supply and motor. The stator voltage reduced from its base value by increase offering angle of thyristor from 0 to 180.

MATLAB SIMULATION FOR SINGLE PHASE INDUCTION MOTOR

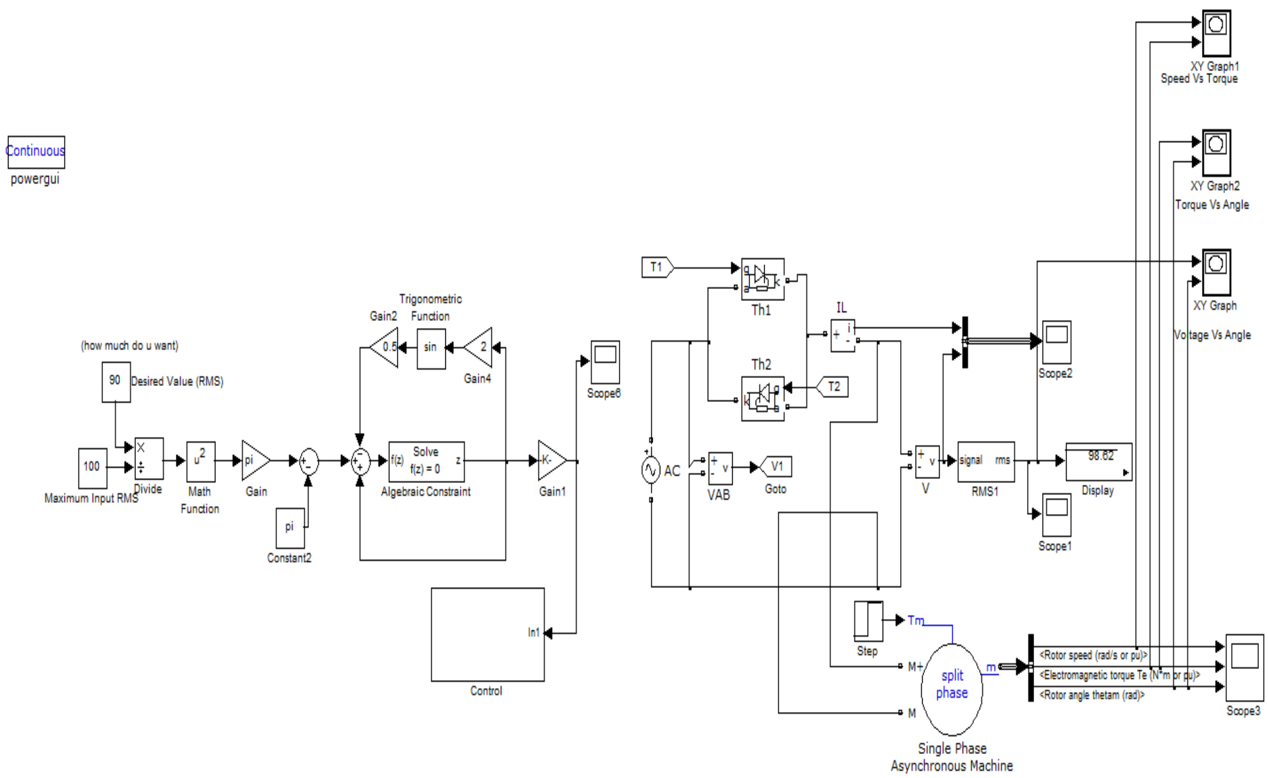


Fig 5.1 simulation model

The figure show the Simulink modelling of thyristor controlled power for induction motor. In the model of thyristor control the power of induction model , hardware is different to Simulink because hardware have rectifier voltage regulator, opto isolators and 8051 micro controller to generate the pulse bit in Simulink we use the pulse generator to generate the pulse.

Result and Discussion

Result and discussion the modelled circuit was simulated and the results were obtained. the input waveform obtained from the alternating current (AC) signal 220v single phase power line is shown in the figure.

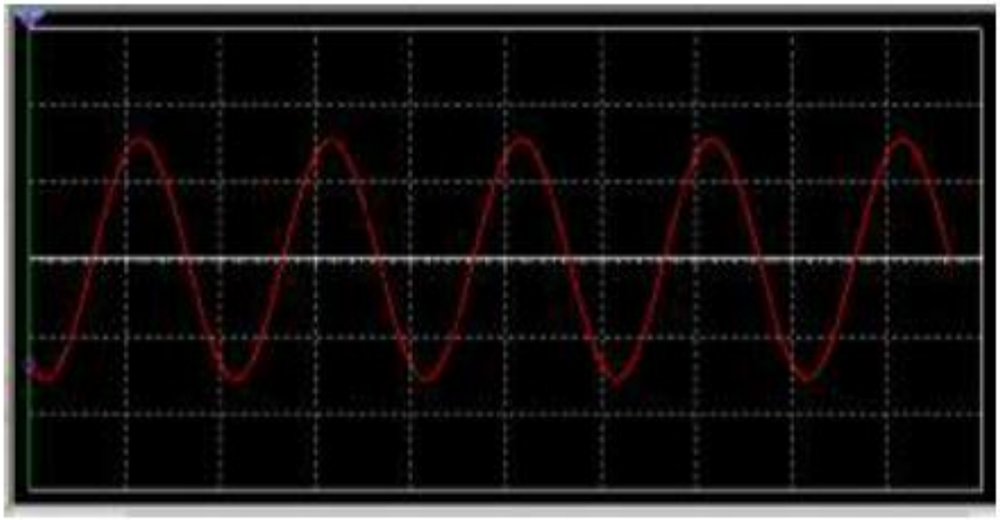
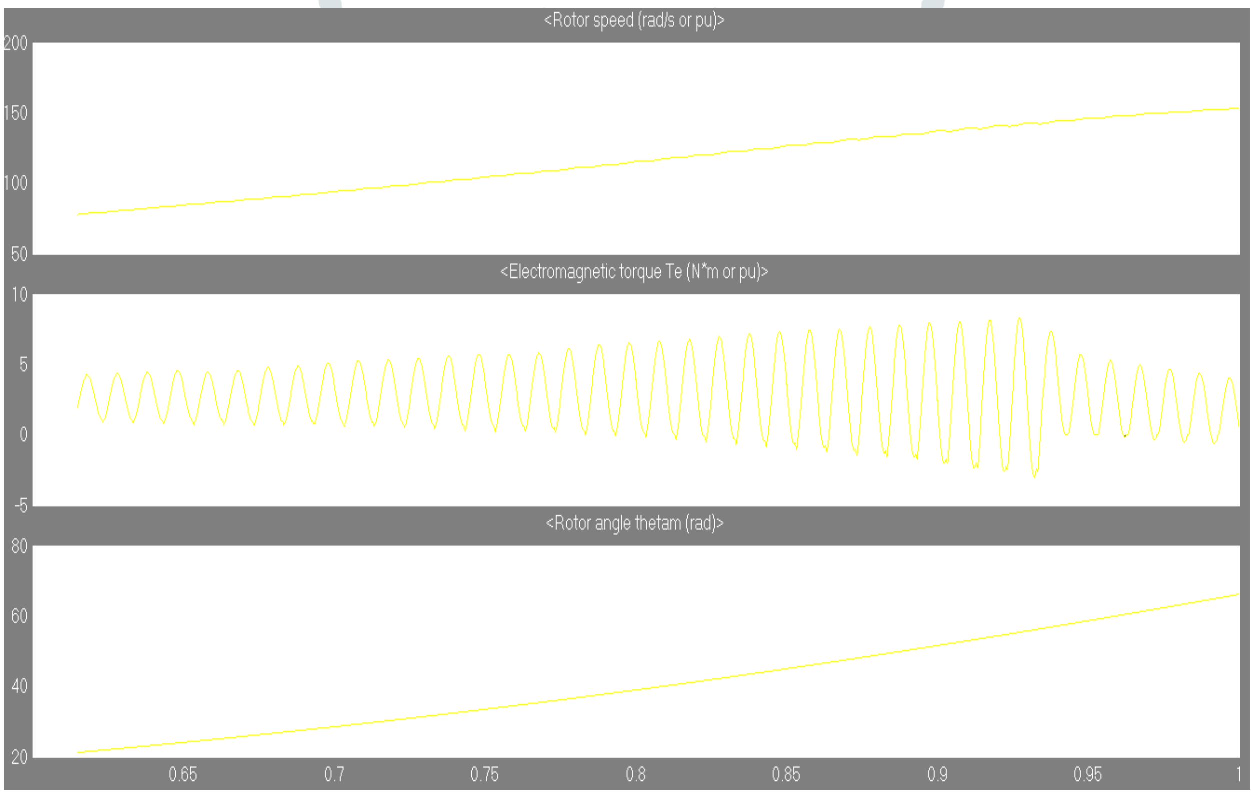


Fig 5.2 Input AC Signal Voltage 220V

The above signal is fed into the relaxation oscillation circuit to generate an "on" and "off" signal which turns the thyristor "on" and "off" at a present value of potentiometer.



Time

Fig 5.3 waveform of simulation

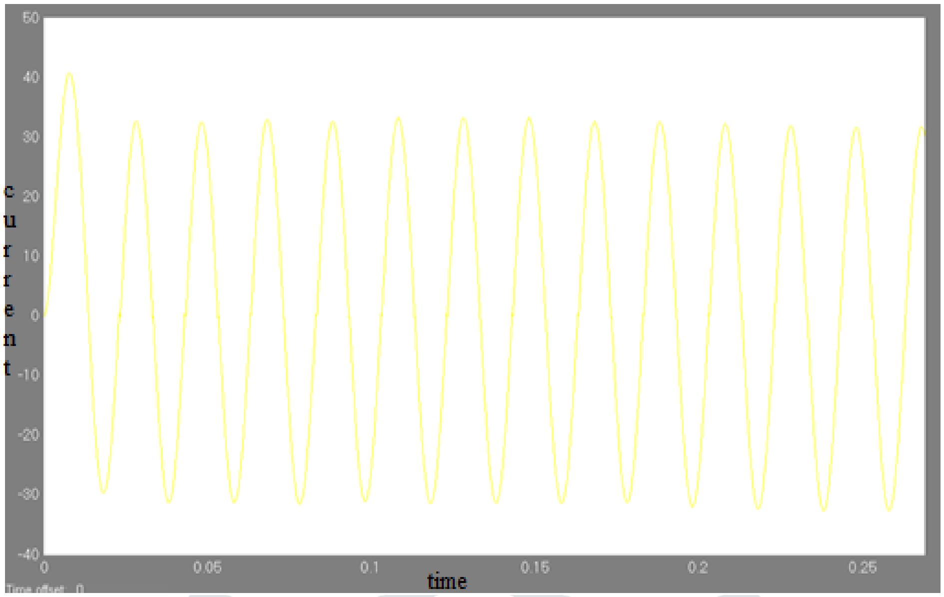


Fig 5.4 Current Vs Time

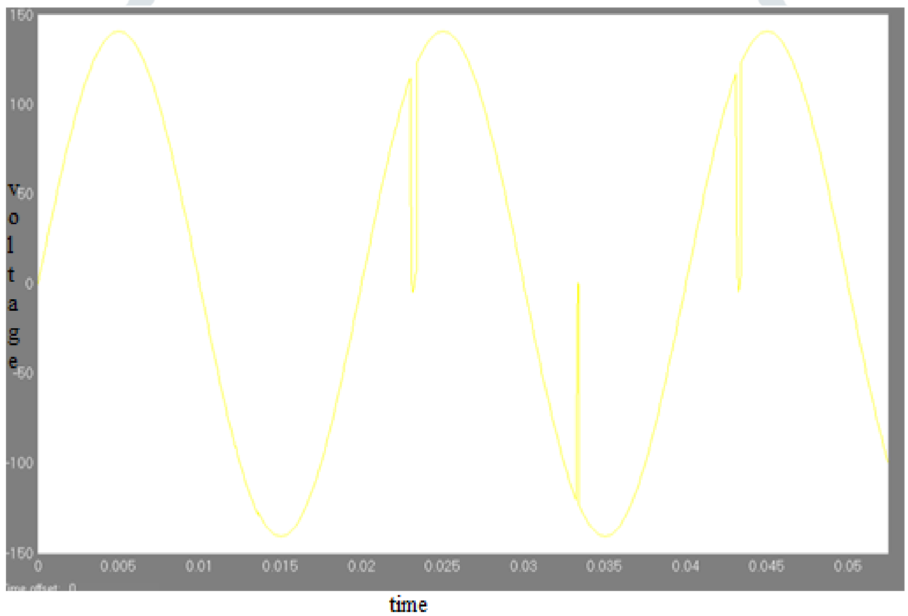


Fig 5.5 Output voltage Vs Time

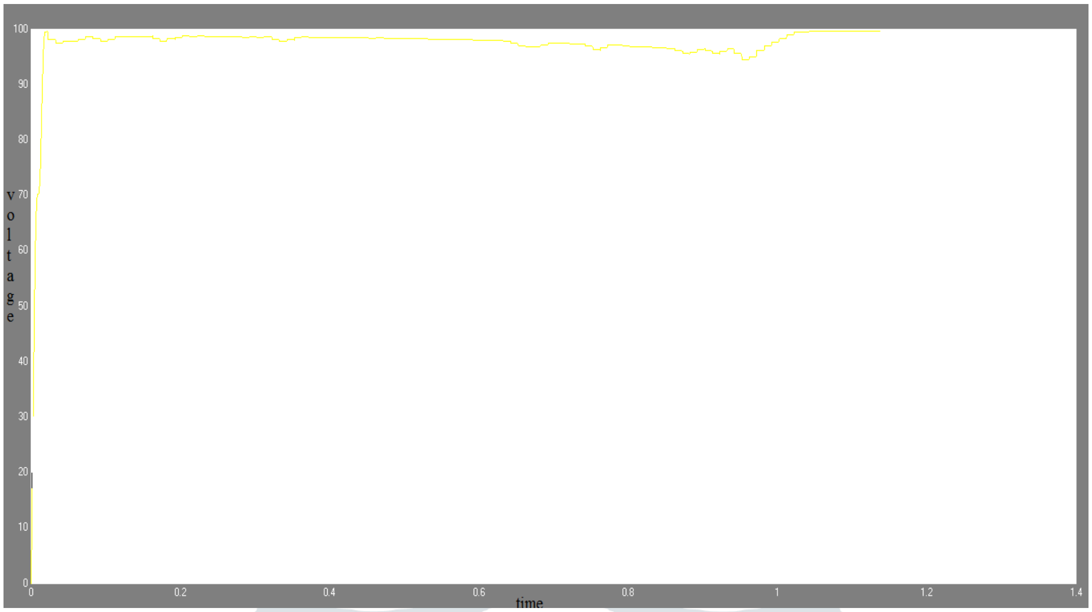


Fig 5.6 RMS Voltage Vs Time

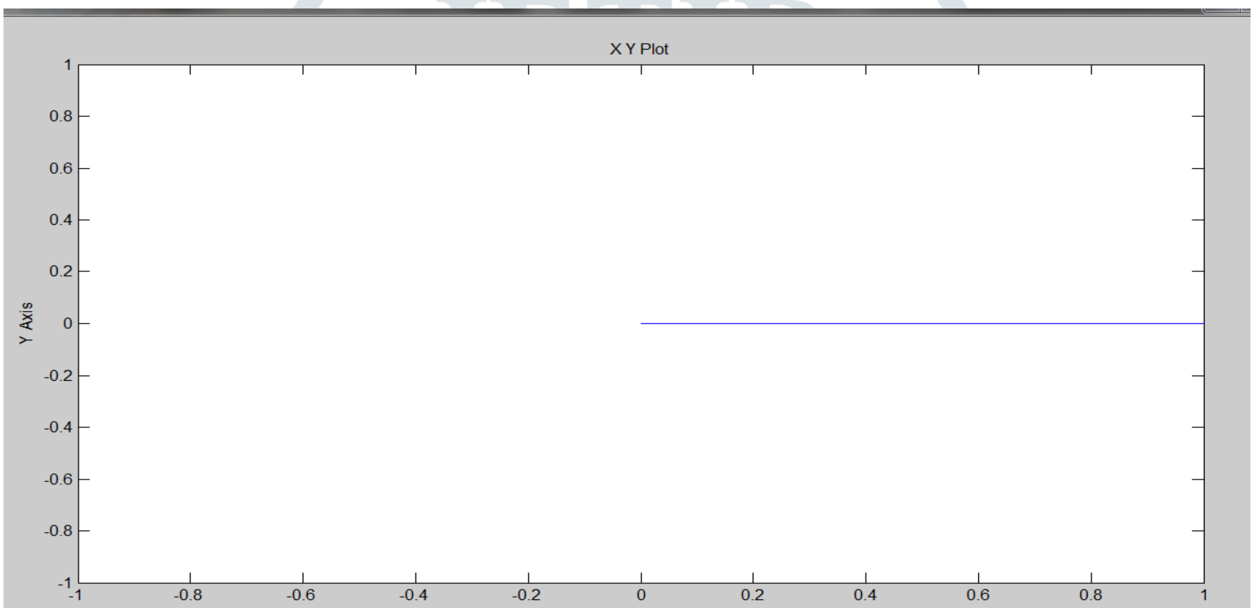


Fig 5.7 Voltage Vs Angle

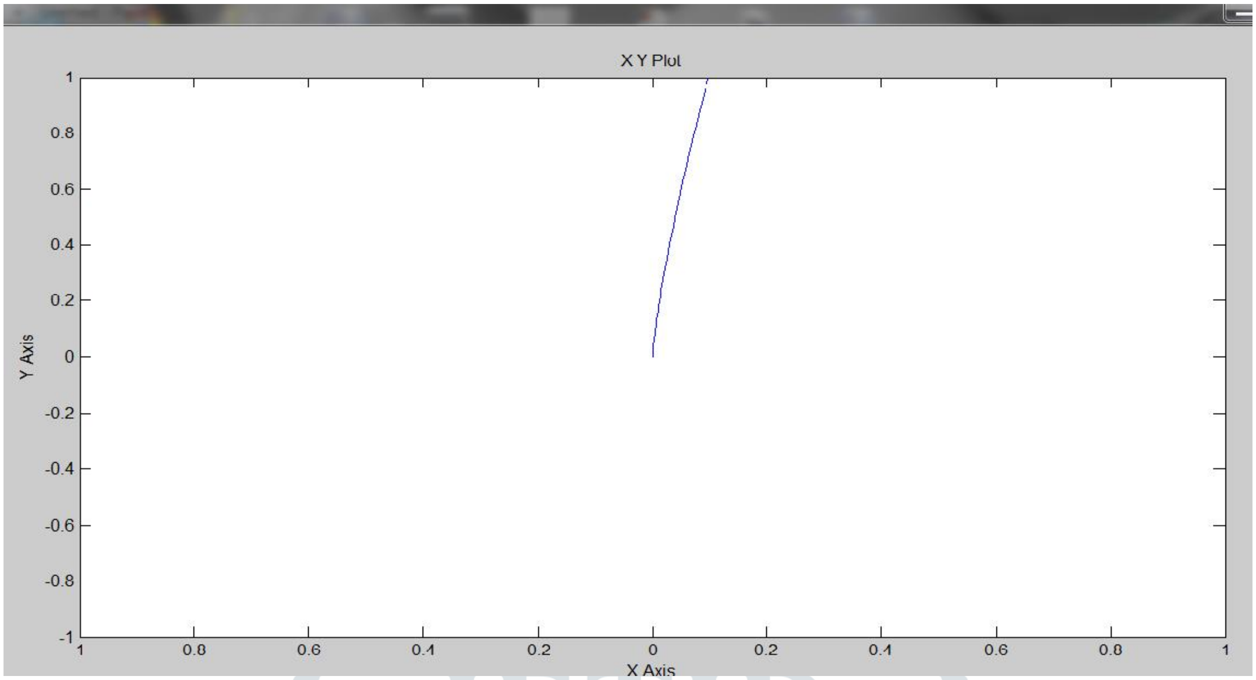


Fig 5.8 Speed Vs Torque

The above waveform shows that as the firing angle is been varied by adjusting the value of the potentiometer, the conduction angle is also varied and thereby the output voltage supplied to the load is been controlled. The values of potentiometer when a is varied were obtained and illustrated.

CONCLUSION

This presents a modeling and simulation of single phase AC voltage control for single phase induction motor the simulation results from multisim software have been found in correlation with their counterpart from MATLAB. The speed control of induction motor is achieved by controlling the firing angle. The relation between the speed of the motor and the firing angle depends on the mode of operation and the phase voltage supplied .Most of the national electrical energy is been consumed by the electrical motor both of the domestic and industrial premises, therefore the implementation of power electronic control provide a larger percentage of energy conservation. In this project we control the AC power to the load by using the firing angle control by thyristor.

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