CHAPTER 1

INTRODUCTION

1.1 GENERAL

An induction motor is a type of asynchronous Alternating Current (AC) motor where power is supplied to the rotating device by means of electromagnetic induction. The Single Phase Induction Machine (SPIM) is the most widely used machine, due to its advantages of simplicity in construction, and reliability in operation. It is widely used in industry, as well as in domestic applications. Recent developments in power electronics have widened the use of AC electrical machines instead of Direct Current (DC) electrical machines in industrial applications. Due to these factors induction motors are now the preferred choice for industries.

1.2 LITERATURE SURVEY

Due to the growing demand for improving the performance of motor drives, there is an increasing need to improve the quality and reliability of the drive circuit. AC-to-AC converter schemes using Pulse Width Modulation (PWM) have been proved to achieve substantial advantages over conventional line-commutated AC controllers. Transistor-controlled AC voltage regulators, operating at the medium-to-high frequency chopping mode and utilizing the pulse width modulation technique, appear to offer attractive alternatives to thyristor-controlled regulators in low and medium power applications of AC power conditioning systems (Hamed 1990).
An optimal control strategy can be applied for selecting the firing and commutation angles in the pulse-width-modulated AC/AC chopper-type converter to eliminate selected harmonics in single-phase converters (Deib 1993). The method minimizes the output-voltage harmonic distortion through numerical techniques, and can also simultaneously eliminate certain chosen harmonics. The best results are obtained when no harmonics are completely eliminated, but instead are allowed to have small residual values. The total rms ripple voltage of the AC/AC chopper-type converter is independent of the firing strategy. However, the harmonic spectrum depends on the firing strategy. The asymmetrical waveform results in lower ripple voltage than the symmetrical one under the same fundamental output voltage. Minimizing a weighted measure of the output voltage harmonics reduces low order harmonics for both symmetrical and asymmetrical waveforms. However, the asymmetrical waveform results in fewer harmonics. The optimal solution becomes closer to the symmetrical case if the number of pulses is higher than nine pulses per half cycle.

Amin (1999) developed the ABC/abc model of the three phase induction motor in the natural reference frame. He also developed the Asymmetrical Pulse-Width Modulated (APWM) AC chopper to drive this model. This model is general enough to simulate most of the AC chopper control algorithms as applied to induction motors. The model is used to explore several characteristics of the proposed APWM controller. The characteristics of the APWM controller are compared with those of the conventional AC chopper controllers. The powerfactor offered by the APWM technique is higher than those offered by both the PWM and the Phase Angle Control (PAC) techniques. On the other hand, the distortion factor of the APWM technique increases as the output voltage increases. As a remedy, at high values of output voltage the APWM controller must operate at smaller values of β.
The transformer with the tap changer and the pulse width modulated AC chopper are combined in a step-up/down AC voltage regulator (Do-Hyun Jang 1998). The regulator can step up or down the output voltage to input voltage. Also, the regulator restrains more harmonics of the output voltage compared to the conventional PWM regulator. The input current flows continuously in the regulator, while it flows discontinuously in the conventional PWM regulator. Therefore, the total harmonic distortion at the supply or load side is decreased. Also, the total harmonic distortion at the input or load becomes lower inversely according to the number of taps. The proposed regulator presents a heavier weight and higher volume because of the transformer in the power circuit. Its manufacturing cost is also higher.

Due to the above drawbacks of the asymmetrical pulse width modulation and step up/down configuration, in this research work, a symmetrical pulse width modulation is considered. There are various types of symmetrical pulse width modulation. The literature has been collected and the survey has been made in this area. A brief account of these documents is given here.

Switching angle control strategies are designed to eliminate a selected number of unwanted harmonics in the chopper type AC voltage regulator. The number of harmonics eliminated equals the number of pulses in load voltage per half cycle minus one. Using a microprocessor as a controller makes it possible to vary the firing instances according to a predetermined timing regime. By adjusting the firing instances, the selected dominant lower order harmonics can be eliminated. This leads to an improved system powerfactor and efficiency (Addoweesh 1990).

A PWM AC controller using forced commutated devices has important advantages compared with a line-commutated AC controller with thyristor technology. These advantages include sinusoidal input-output
current/voltage waveforms, smaller input/output filter, better input powerfactor and better transient response. The performance of a three phase PWM AC controller using only four switches is described (Lautaro Salazar – 1993).

Recent developments in the field of power electronics make it possible to improve the electrical power system utility interface. Line commutated AC controllers can be replaced by pulse width modulated AC chopper controllers, which have better overall performance. The above problems can be solved if these controllers are designed to operate in the chopping mode (Ahmed 1999, Lucanu 2003).

The configuration of an AC chopper with four switches and DC snubber is described by Takayuki Shinya (2002). The DC snubber is achieved by dividing an input filter capacitor into two parts. The performance analysis proved that this configuration improves the system powerfactor and reduces its harmonics compared to the phase-controlled system.

The modulation function for the pulse width modulation technique is derived from the input voltage signal. Compared with the constant duty cycle control, it has the advantage of eliminating all the low order harmonic voltage contained in the AC mains without the need of processing the harmonic frequency. Hence, it reduces greatly the demand for the bandwidth of the controller and simplifies the control scheme (Yu Hongxiang 2004).

A method of voltage harmonic elimination in a pulse-width modulated AC/AC voltage converter using the genetic algorithm is proposed by Sundareswaran (2004) and Srinivasa Rao (2005). Using the Fourier series, the output voltage of the AC chopper with ‘p’ pulses per half cycle is written in terms of the switching angles. The best switching angles are identified with the dual objectives of harmonic elimination and output voltage regulation.
Lucanu (2005) described two circuits of single phase AC choppers with inductive load to improve commutation. The waveforms of the current generated by the AC power supply remain very good. The efficiency increased significantly.

Power quality describes the quality of voltage and current and is one of the most important considerations in domestic, industrial and commercial applications. The power quality problems commonly faced are, transients, sags, swells, surges, outages, harmonics and impulses. Among these, voltage sags and extended under voltages have the largest negative impact on industrial productivity and could be the most important type of power quality variation for many industrial and commercial customers. Using a switch mode AC voltage regulator, constant voltage across a medium sized domestic or commercial appliance is maintained (Ahmed 2006). It has the ability of delivering sinusoidal input current with nearly unity powerfactor and the efficiency of the regulator is high. This system incorporates high-speed Insulated Gate Bipolar Transistor (IGBT) switching technology.

A single phase bi-directional AC power controller comprising Metal Oxide Semiconductor Field Effect Transistor (MOSFET) embedded discrete component four quadrant switch realizations for supplying controllable AC voltage has been tested (Arvindan 2006) with resistive load for experimental validation of the theoretical analysis of the output voltage harmonics. The harmonic analysis reveals that with resistive load, for the same per unit output voltage, both Symmetrical Multiple Modulation (SMM) and phase control methods yield the same input powerfactor. However, in SMM control, the harmonic profile can be changed for selective harmonic elimination, while harmonic reduction is possible by manipulating the number of pulses per half cycle.
A four-quadrant high frequency AC chopper has the ability to handle reactive loads without the need for a dead time between switches. This is accomplished by dynamically configuring the chopper as positive or negative buck or backward boost converters, corresponding to the momentary polarities of the input voltage and output filter inductor current (Sam Ben-Yaakov 2006).

Meco-Gutierrez et al (2007) have described an alternative technique, which involves the same number of commutations per unit time, and therefore, causes the same amount of heating in the transistors, while generating an output signal with an appreciable increase in the fundamental component and a significant reduction in the lower order harmonics, which are most difficult to filter. A motor connected to the converter undergoes less overheating and vibrations, thereby improving its performance. To achieve this, the modulating wave is compared with a triangular carrier with variable frequency over the period of the modulation. It is therefore convenient for the modulating signal to have a lot of sinusoidal ‘information’ in the areas of greater sampling.

Selective – harmonic – elimination – pulse – width – modulation techniques offer a tight control of the harmonic spectrum of a given voltage waveform generated by a power electronic converter along with a low number of switching transitions (Al-Othman 2007). The output voltage harmonics elimination and voltage control of PWM AC/AC voltage converters using the principle of hybrid real-coded genetic-algorithm-pattern search method is discussed. With this method, the complete elimination of the desired harmonics is possible, but it has to be at the expense of time and much computational effort.

Jegathesan et al (2008) have presented an efficient and reliable genetic algorithm-based solution for specific harmonic elimination switching
pattern. For determining the pulse pattern, for the elimination of some lower order harmonics of a PWM inverter, genetic algorithm is used. Without using the dual transformer, harmonics up to 17th order are eliminated.

Ramkumar et al (2009) have described the method to extend the linearity of the Sinusoidal Pulse Width Modulation (SPWM) to full range of the pulse dropping region. The amplitude modulated triangular carrier PWM method increases the dynamic range of the SPWM control and eliminates the need of nonlinear modulation in the pulse dropping region to reach the square wave boundary.

A modular simulink implementation of an induction machine model is used in different drive applications, such as open-loop constant v/f control and indirect vector control. With the modular system, each block solves one of the model equations; therefore, unlike the black box models, all the machine parameters are accessible for control and verification purposes (Burak Ozpineci 2003).

In this research work, the double field revolving theory is effectively used to obtain the simulink model of a single phase induction motor. When the two fields are known, the torque produced by each field can be obtained. The difference between these two is the net torque acting on the rotor. Using the double filed revolving theory, the equivalent circuit of the single phase induction motor is obtained. A set of equations is derived from this equivalent circuit, and the simulink model of a single phase induction motor is developed. The modeling of the single phase induction motor is explained in Chapter 3. The developed simulink model of the single phase induction motor is used for simulation.

The single phase induction motor is widely used in industry, as well as in domestic applications. The open loop speed response of the
induction motor is obtained with a constant duty-ratio. But open loop
operation may not be satisfactory in many applications. As most of the drives
require constant speed operation, the firing angle is changed to maintain
constant speed. This is achieved in the closed loop control system. The speed
control in the closed loop system is implemented using the proportional -
integral (PI) and neural network controllers.

Eliminating the starting capacitor and the centrifugal switch
increases the efficiency and improves the starting torque of the motor. Only a
running capacitor is used (Tian-Hua Liu 1997). The elimination of the
running capacitor will enable the motor to perform well, at low speeds.
Increasing the speed limit is correlated with an increase in the drive’s cost and
complexity. Consequently, if the price aspect is less important than the
performance of the drive, the capacitor-less solution for the drive should be
chosen for driving the speed of a single phase induction motor, a chopper
circuit is employed on the motor (Frede Blaabjerg 2002).

For controlling the stator side (Makky 1995), the chopping switch
is placed across a diode rectifier bridge, which terminates the stator winding
from the opposite side to the supply. By changing the chopping frequency the
rotor speed changes. The ratio of the voltage to frequency can be kept
constant by using phase control in addition to frequency control. However,
remarkable speed ripples accompany low chopping frequencies.

The speed control of the AC series motor is achieved using both the
phase controlled system and pulse-width-modulated systems. It is observed
that the pulse width modulated AC chopper fed series motor has improved
powerfactor and lesser harmonics (Sivaranjani 2006). The performance of the
single phase induction motor using a microcontroller is investigated by Bashi
(2005) and Hamad (2004). The microcontroller senses the speed’s feedback
signal and consequently provides the pulse width variation signal that sets the
gate voltage of the chopper, which in turn, provides the required voltage for
the desired speed. A buck chopper is used to control the input voltage of a
fully controlled single phase isolated gate bipolar transistor bridge inverter.
The PWM technique has been employed in this inverter to supply the motor
with AC voltage.

Ahmed (2000) described the implementation of a symmetrical
PWM AC chopper fed single phase induction motor. The control of the motor
voltage is achieved by varying the duty cycle of the switching function.
Besides the wide and continuous range of control, the relation between the
fundamental component of the motor-applied voltage and the duty cycle is
linear over most of the control range. Due to the nature of the switching
process and high switching frequency, the lower order harmonics both in the
motor and supply sides are reduced, and the order of the lowest harmonic is at
the sum/difference of the switching and supply frequencies. The results
present the first step toward the use of PWM AC choppers with the speed
control of induction motors.

A minimum-time minimum-loss control strategy for induction
motor drives has the straightforward goal of minimizing the speed drop in the
transient state, i.e., track the reference speed as fast as possible over the entire
speed under allowable constraints of current and voltage, and provide
maximum efficiency of the drive system when the speed returns to its
reference (Barra 2005).

An Optimal Efficiency Control (OEC) of the three phase induction
motor, fed by an AC chopper with a pulse width modulated controller, based
on the concept of the Instantaneous Power Theory (IPT) provides many
advantages, such as improvement in efficiency and energy saving, limiting
harmonic currents, and unity powerfactor at the mains side (Bilal Saracoglu 2004).

In industrial units like a punching press, most of the induction motors often run at no-load or partial load. These motors are always connected to the mains irrespective of the load conditions. Due to the rated voltage at the stator terminals, rated iron losses have to be supplied constantly to the motors. These losses mean a waste of some form of primary energy, whose availability on our planet is limited. If it is possible to reduce the voltage at the stator terminals during no-load or small duty-ratio load conditions, then the iron losses can be reduced and some electrical energy, and primary energy, might be saved.

The problem of efficiency optimization in a single phase induction motor is examined by Christos Mademlis (2005). They have presented a theoretical analysis of the problem and an optimal efficiency condition relates to the currents of the two-stator windings. Through the optimal condition, the supply voltage is adjusted according to the load torque requirements. A triac-based optimal control scheme for accomplishing efficiency optimization in the single phase induction motor is considered. The magnetic and torque performance of the same single phase induction motor that was used in the experiments with nominal, optimal variac, and optimal triac-controlled voltage excitation, is investigated and compared. It is validated that magnetic saturation considerably decreases with optimal efficiency control.

As the three phase induction motor is operated in the regenerative mode, much energy can be saved (Tipsuwanporn 2006). In this mode, the energy flows back into the DC link voltage, and causes high voltage to occur in the capacitor that may destroy the capacitor and switching component such as the IGBT. Two fuzzy controllers are introduced to manage the duty cycle
of the buck converter, and to control the switching component of the braking circuit.

Energy can be saved in three phase induction motors when they operate under long-term light-load or small duty-ratio load (Xue 2006). Here, the variable voltage control at constant speed principle is used. The motor controller for energy saving is developed. Induction motors have a high operating powerfactor and efficiency when they run in the load range of 75% to 100% full load. Thus, a high operating powerfactor and efficiency can be obtained when induction motors run at full load or near full load. However, induction motors have low operating powerfactor and efficiency when they run at no-load or light-load. For an induction motor drive system, the selection of the rating of the induction motor depends mainly on its maximum load. In real applications, however, the load changes with the actual requirement. Hence, there are often cases where induction motors with large ratings are used to drive small loads or small duty-ratio loads. This will result in induction motors running with a low powerfactor and efficiency at light-loads or small duty-ratio loads. The control scheme introduced by Xue automatically adjusts the output voltage of the controller with the variation in the load, in order to obtain a high operating powerfactor and efficiency, and to implement energy saving.

The novel soft starter based on self-commutated switches for induction motors is described by LiGuangqiang (2004). By analyzing the principle of the presented soft starter, it has been shown that its control is easier than the thyristorized soft starter, and it can eliminate the lower order harmonics. Comparing the two soft starters regarding energy conservation, the following conclusions can be obtained. The proposed soft starter can improve the efficiency of the drive system with light load. Compared with the thyristorized soft starter, the novel soft starter does not produce the lower-
order harmonics. Under the same operating condition, it has a higher power factor, large power saving, and smaller input current.

When fixed-speed motors are purchased for new installations or for replacements, the loaded shaft speed differences among the motor options are either ignored or overestimated. The most common first-cut estimate is that the consumed shaft power will vary according to the cube of the ratio of the motor rated nameplate speeds for centrifugal driven loads. In actuality, this is true only if the motors are loaded at approximately at nameplate output. The true “control valve loss” factor takes into account actual speed differences among motor options (Hamer 1997). A simplified equation and figure are presented to permit a quick evaluation of motor purchase alternatives for the lowest life-cycle cost, based on efficiency and rated-load speed differences.

The PWM AC chopper fed induction motor drive finds application in energy saving operations and soft starting (Hunyar 2001). The operation with minimum power loss is realized by means of a motor terminal impedance control with subordinated current loop. The operation of the drive is controlled by a microcomputer based on a TMS32010 digital signal processor. It provides high computing power for the necessary calculations.

For the single phase application, a step-down AC voltage regulator using an AC chopper with a series transformer can be used for power saving purpose of single-phase AC loads, such as lighting of the street. When high luminous intensity is not required, by decreasing the supply voltage to 10-20% of the rated voltage, the power can be saved (Ryoo 2003).

A control technique based on a neural network is proposed here, for the constant speed control of induction motor drives. In the industry, the Proportional, Integral (PI) or Proportional, Integral and Derivative (PID) controller is widely used. These controllers show excellent ability if a simple
control is to be implemented. The fundamental difficulty with PID control is that it is a feedback system, with constant parameters, and no direct knowledge of the process and hence overall performance is reactive. To solve this problem, the conventional controllers are replaced by neural network controllers. These adjust themselves to control circumstances and show a reduced maximum overshoot.

Recent developments in Artificial Neural Network (ANN) technology has made it possible to train an ANN to represent a variety of complicated nonlinear systems. The ANN can be trained to solve the most complex non-linear problems with variable parameters. The ANN has been successfully applied to identify and control the speed of an induction machine.

Various kinds of neural network architecture in the vector-controlled induction motor drive are studied (Bose 2001). Most of the current ANN applications are restricted to feed forward backpropagation type networks. Three phase current source PWM rectifiers are used as front-end AC/DC converters. This can significantly increase the input powerfactor and reduce the line-side harmonics in adjustable speed drive systems. They can therefore meet strict specifications on the harmonics injected into the AC mains, which will eventually be introduced in the near future. Three phase current source PWM rectifiers are generally operated with off-line PWM patterns. This results in non-unity input displacement factor and possible large inrush current due to the presence of the input LC filter. Moreover, the input displacement factor is dependent upon the operating point, and the response to transient conditions is slow. An on-line neural network controller can be used to wave shape the input line currents of the rectifier (Insleay 1994). Unity powerfactor operation is maintained and the low frequency resonance of the input filter is effectively damped without the need for large damping resistors.
With a two-degree-of-freedom controller with its parameter adaptively tuned by neural network, the desired drive specifications can be achieved under wide operating ranges (Kung 1995). A systematic design procedure is derived to find the parameters of the two-degree-of-freedom controller according to the known drive model and the given specifications. To cope with the variations of the system parameters resulting from the changes in the environment and operating conditions, an adaptive mechanism combined with system identification and neural network techniques is used to tune the parameters of the two-degree-of-freedom controller.

As long as the parameters of PID control, proportion gain, integral gain, differential gain and sampling period are optimized and tuned, conventional PID control shows better performance and higher control precision. However, the PID control is weak when the parameters of model change. The neural network PID control, which is a method for adaptively adjusting the PID gains using a backpropagation algorithm, can be adopted. The neural network PID control has the capability of self-study and self-adaptation (Jiangjiang Wang 2007).

Cirstea et al (2001) have described the Field Programmable Gate Array (FPGA) implementation solution alongside with a control method that avoids part of the intricate calculations used by classical sensorless vector control strategies. This approach is based on an equivalent R-L-e circuit of the induction motor. The sensorless control of the induction motor is transformed into a control strategy referring to the quantities in the equivalent R-L-e circuit.

In many practical problems the task is the control of a non-linear plant, under parameter uncertainty, by a controller of known structure that uses the values of the state variables. Theocharis et al (1994) have described that this type of problem arises from the control requirements of an induction
motor and is tackled by neural-network-based observer techniques, so that the state variables are estimated while the variations of the unknown parameters are compensated for. A neural network based adaptive observer performs the observation task. The observer is designed to provide the rotor flux magnitude estimate. It continuously tunes the slip speed command, thus leading to a decoupling of the rotor flux terms. The proposed observer comprises of two neural networks, which are trained to learn the rotor flux and the stator model dynamics, respectively. Adaptation is performed on the basis of the stator voltage prediction error. The error signal is used to modify the connection strengths so that the neural observer can follow the changes due to the rotor time constant variations motor dynamics.

Off-line trained artificial neural networks are applied for creating system inverse models. They are used for designing a control algorithm for non-linear dynamic systems (Jaroslava Zilkova 2006). The design of a neural controller is based on sensor information pertaining to the angular speed and stator current of the induction motor. The neural controller consists of two cascade feed forward neural network subsystems. The first subsystem of the neural controller serves to reconstruct the current components, and the second subsystem serves to reconstruct the corresponding voltage components for the PWM converter.

A controller based on an adaptive neuro fuzzy inference system for voltage space-vector generation has been described by Buja (2004). It combines fuzzy logic and artificial neural networks for decoupled flux and torque control. In the scheme, the error signals are delivered to the neuro fuzzy controller, which is also entered by the actual position of the stator flux vector. The neuro fuzzy controller determines the stator voltage command vector for the space vector modulation block.
Bouhali et al (2005) have described a novel concept of the application of artificial neural networks for generating the optimum switching functions for the voltage and harmonic control of bridge inverters. In many research works, the neural network is trained off-line using the desired switching angles given by the classic harmonic elimination strategy to any value of the modulation index. This limits the utilisability and precision in other modulation index values. In order to avoid this problem, a new training algorithm is developed without using the desired switching angles but it uses the desired solution of the harmonic elimination equation.

Chun che fung (2005) compared the performance of four different neural networks namely Polynomial Neural Network (PNN), General Regression Neural Network(GRNN), Backpropagation Neural Network(BPNN) and Probabilistic Neural Network (PrNN). He also described the applications of these networks. Drays et al (1996) have described the dynamic features of a neural network model, which presents two types of adaptive parameters: the classical weights between the units and the time constants associated with each artificial neuron. This study provides a strong theoretical basis for modeling and simulating dynamic recurrent neural networks. In order to achieve this, the effect of the statistical distribution of the weights and of the time constants on the network dynamics was studied and a statistical analysis of the neural transformation was made. They examined the network power spectra and computed the stability regions to explore the stability of the model. They have shown that the network is sensitive to the variations of the mean values of the weights and the time constants.

Jun Oh Jang (2007) discussed about the neural network compensation scheme for systems with actuator saturation. He has designed a proportional derivative-tracking loop with an adaptive neural network system in the feed forward loop for actuator nonlinearity compensation. The
saturation-compensation signal is inserted into the actuator-control signal. Using non-linear stability techniques, the bound on the tracking error is derived from the tracking-error dynamics. Neural network weights are tuned online, and the overall system performance is guaranteed using the Lyapunov function approach.

The application of backpropagation neural networks to a self-tuning adaptive control of unknown, non-linear and feedback linearizable plants is examined by Kulawaki (1994). They present the application of this algorithm to the control of the complex time varying object. Based on the principle of the operation of the neural controller, which is based on the identification of a local non-linear model of a plant, this seems competitive to the traditional techniques relying on local but linear approximation.

Indirect field orientation induction machine drives are increasingly employed in industrial drive systems, but the drive performance often degrades. Motors register the best performance at certain voltage and frequency, for certain loads. Sharma et al (2007) have described that an artificial neural network is used to predict the operating voltage and frequency when the load torque and speed are changed, so that motor efficiency is increased. A neural network is automatically trained by comparing the actual voltage and frequency with the sample corresponding data. The motor flux is the ratio of optimum voltage and frequency. So this flux is compared with the reference flux and it generates the error signal and controls the action of the induction motor.

The above literature does not deal with the neural-network-based control of a bidirectional chopper fed induction motor drive system. In the present work, a new simulink model of a single phase induction motor using the double field revolving theory is developed. The neural network based closed loop speed control for the single phase induction motor drive system is
developed. The scholar is unaware of simulation and implementation of energy saver for single phase induction motor. The neural network based energy saver for single phase induction motor drive is developed.

1.3 OBJECTIVES OF THE THESIS

The objectives of the investigations carried out can be summarized as follows:

- To find the improved pulse width modulation technique to overcome the drawbacks of the phase controlled AC chopper system.
- To model the PWM chopper fed induction motor drive using blocks of simulink.
- To simulate the neural network based speed control of the single phase induction motor.
- To save energy during no-load and partial load periods using an artificial neural network control scheme.
- To implement the hardware of embedded controlled single phase induction motor.

In order to validate the analysis and design of the above converters and to verify the effectiveness of the control technique, MATLAB/SIMULINK software is used. ATME 89C2051 microcontroller is used to ascertain the effectiveness of the control techniques in real time.

1.4 ORGANISATION OF THE THESIS

The thesis is divided into seven chapters. The organization of the thesis is as follows:
The first chapter presents the general introduction to the problem and the previous investigations reported in the literature. It concludes with the statement of the main objectives of the work presented in the thesis.

The second chapter analyses the working and operation of the various configurations of the pulse width modulated AC chopper. The simulation circuits and results are presented.

The modeling of the single phase induction motor using the double field revolving theory is dealt with, in the third chapter. The simulink model of a single phase induction motor is presented.

Chapter four describes the speed control of the single phase induction motor using conventional and neural network controllers. The performances of both the controllers are compared.

The design of the neural-network-based energy saver is presented in the fifth chapter.

Chapter six describes the experimental verification of the pulse width modulated AC chopper system.

Chapter seven gives the conclusion and scope for further research work.

1.5 CONCLUSION

The literature review, objectives and organization of the thesis are presented in this chapter.