**SOFT SWITCHING INVERTER**

**ABDUL GHAFFUR BIN MOHAMMAD MOHSIN**

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**This Report Is Submitted In Partial Fulfillment of Requirements for the Degree of Bachelor in Electrical Engineering**
**(Power Electronic Actuator & Drives)**

**Fakulti Kejuruteraan Elektrik**
**Universiti Teknikal Malaysia (UTeM)**

**April 2009**

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic Actuator & Drives)"

Signature : ……

Supervisor's Name : …….

Date : …….

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

Signature : ……

Name : Abdul Ghaffur Bin Mohammad Mohsin

Date : 22 / 04 / 2009

For my beloved father and mother

Mohammad Mohsin Bin Hj Mohd Sidek and Noor Riza Binti Hj Ahamad

In appreciation of supported and understanding.

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# ABSTRACT

Gate driver circuit is important device for application of motor. Many technique for control motor drives were introduce from previous , such as using PWM (pulse width modulation), BRM (binary rate modulation) etc. Based on that technique the proposed system are used the optocoupler device to develop the PWM. In addition that device more simple and easy to handle the operation to produce the required PWM. Beside that, the microcontroller PIC is used to program and control the motor drives. So the motor load can be operated forward or reversed biased by PIC.

# ABSTRAK

Litar pemacu adalah alat penting bagi menjalankan sesuatu motor. Banyak teknik untuk menjalankan jentera motor telah diperkenalkan dari terdahulu lagi, seperti menggunakan PWM (pemodulatan lebar denyut), BRM (modulasi kadar perduaan) dan sebagainya. Berdasarkan teknik itu cadangan sistem digunakan alat optocoupler untuk membangunkan PWM. Tambahan pula alat itu lebih mudah dan mudah mengendalikan operasi untuk mengeluarkan dikehendaki PWM. Di samping itu, mikropengawal PIC adalah digunakan untuk memprogram dan kawalan menjalankan operasi motor. Supaya motor boleh dikendalikan ke hadapan atau dibalikkan bergantung kepada kecenderungan PWM oleh PIC.

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# CHAPTER 1.0

# INTRODUCTION

## 1.1 BACKGROUND

Power electronics are an enabling technology and interface multiple systems with different requirements. As such, constraints are applied to power electronics systems by outside variables such as the load, source, environmental factors, life span requirements, packaging and cost; all of these must be weighed and balanced to create an optimal power electronics solution for an application. Soft-switching topologies offer the promise of increasing power density, reducing life cycle costs, and reducing the detrimental effects of electromagnetic interference (EMI) on any vulnerable electronics.

Soft-switching inverters are of keen interest to researchers and product designers alike for their many beneficial characteristics. Many papers have been written on soft switching inverters describing the characteristics of various different topologies. Though various topologies excel in different areas, the general family of soft-switching inverters has several possible advantages over traditional hard-switching inverters.

- Higher efficiency – Soft-switching inverters significantly reduce the amount of switching loss in power semiconductor switches and make efficiency less dependent on switching frequency.
- Harmonics and audible noise reduction – If increases in switching frequency are made, the harmonic filtering becomes easier. Additionally,

above 18 kHz there is no longer any audible noise from the power electronics.

- Increased power density – The use of smaller main switch die size is possible because lower switching losses will result in lower device junction temperatures for a given average load current. The efficiency improvements ideally lead to higher power density and smaller cooling system size, but the additional space required for auxiliary components may negate any such benefits.
- Increased switch utilization – Voltage overshoot is reduced and current spikes are minimized allowing the use of switches with lower peak voltage and current ratings.
- Decreased EMI – A normal hard switching application intrinsically has high EMI associated with the high di/dt and dv/dt of the switching process caused by the rapid turn-on and turn-off of the power semiconductors. The rate of these rapid changes can be reduced using soft-switching, reducing EMI.

These aforementioned points are highly desirable characteristics in some applications and considered unimportant in others. This is especially important to take into consideration when considering the drawbacks of soft-switching converters as well as their benefits.

Some prominent production design holdups are:

- Increased component count – soft switching inverters require additional components which increase supply management issues, circuit layout complexity and the overall number of possible failure points in the inverter.
- Increased cost – The soft switching inverter will likely cost more in production than a hard switching inverter due to increased components.
- Design and control complexity – Many soft switching inverters have complex operations that differ from a traditional inverter. This extra complexity usually involves additional control circuitry. Additionally, the overall design process will take longer than the traditional inverter leading to higher engineering costs.

- Reliability questions - Soft switching inverters by nature are not inherently unreliable, but since there are no soft switching inverters in production there is not significant information available about the long term reliability of soft switching inverters in various applications.

**Gate Driver for Induction Motor** is a device that capable to generate a variable frequency modulation or variable magnitude voltage source in such a way it manage to control induction motor operating conditions. The device operates by applying a series of gate pulse at which the pulse width can be adjuster using PIC in accordance to a contain modulation technique. By doing to, the controller induction motor can be made to control at a pried timer operating condition such as speed, torque, and etc.

This project focuses on development of gate driver for single phase induction motor. The idea behind these is that because Ac motors has a numerous advantage are DC motor. Hence, induction motor is commonly used in industry. Ac motors is preferred to control high horsepower compare to the DC motors. This is because AC machine are twenty to forty percent lighter than the DC motors [9]. Besides that, AC motors are inexpensive and requires less maintenance compare to the DC motors.

Along width advance of power electronic, controlling of AC motor drives is becoming easier and cheaper, and mare also becoming a prime interest topic of many researcher. The application of power electronic that used is rectifier circuit and inverter circuit. Rectifier circuit will produce the DC voltage to the inverter from main AC supply. While inverter circuit is used to convert back from DC voltage to AC supply to start the AC motors. There are two type inverter that can be used in order to control the speed and operation of AC motor: voltage source inverter and current source inverter [9]. Mosfet is used as a switch in inverter circuit. Mosfet is preferred because the fast switching time obtainable with them vary little with temperature. Seconds because of the high input impedance of the device, the drive circuitry can be of low power and also compact and simple. The driver that be used for MOSFET in this project is BUZ10 that produce by microchip. The advantages of using power electronics application are:

a) High efficiency because of low 'on state' conduction losses when the semiconductor is conducting and low 'off state' leakage losses when it is blocking the source voltage.
b) Reduce maintenances.
c) Long life
d) Compactness because of the facility of assembling the transistor, diode, and RLC element in common package.
e) Faster dynamic response.
f) Lower acoustic noise.

PWM is signal waveform that can be produce by PIC 16F877A as per the requirement of the inverter based circuit. A technique for the generation of PWM waveform is to store the lookup table of digital words corresponding to pulse and notch width at different magnitudes of fundamental in memory for later conversion into PWM waveform [9].

The advantages of using single phase AC induction motor drives are the operation of motor is more efficient, resulting in longer life, lower power dissipation and lower overall system cost.

In some industrial applications DC motors are preferred because the voltage required by them can be easily varied using DC choppers or controlled rectifier, which are simple and inexpensive. Moreover, separately excited DC motors have a decouple structure. However, the following facts emergency from a look at their disadvantages:

1. A DC machine has a commutator which is expensive and need constant maintenance.
2. The brushes used with the commutator need periodical replacement because constant wear tear.

So this project is expected able to overcome the internet problems of the DC motor. In the recent past, AC motors have replaced DC drives in many applications such as machine tools drives, paper mills, waste water treatment, conveyor and etc. Again, in high horsepower applications solid state cycloconverter fed induction motor drives and [redacted] drives are preferred. This

trend is continuing eventhough the power electronic portion of these AC drives constitutes seventy percent of their total cost [6]. AC drives have the following advantages:

a) AC machine are twenty to forty percent lighter than the DC motors. Besides, AC drives are inexpensive and require less maintenance compare to the DC motors.
b) The advent of silicon controlled rectifiers with high voltage and current ratings as well as Insulated Gate Bipolar Transistor (IGBT) has given impetus to the use of AC drives in application of power ratings of 100 horsepower and above.
c) Easy implementation of complex control algorithms by mean of microcontroller based AC drives. Flexibility can be attributes to the replace ability of hardware circuitry by implementing microcontroller software.

In industrial field, AC motors are very popular to drives a heavy machine. The development of gate drives device together with utilizing power switch the operation of the induction motors can be fully controlled. This is important because, by controlling the operation of motors energy can be reducing. In addition, the cost of production can be reducing.

## 1.2 PROJECT OBJECTIVES

The main objectives of this project are to design gate driver for induction motor control. This project consists of hardware and software. Which as describe as follows:

1. To develop and design the pulse width modulation (PWM) using optocoupler

2. To develop and design the motor driver.

3. To design and control the motor using microcontroller.

4. To develop and design rectifier circuit and inverter circuit in order to provide a drive system for single phase ac induction motor (speed control.

## 1.3 PROBLEM STATEMENT

The problem statement of this project is microcontroller is more stable compare to the microprocessor in order to generate the pulse width modulation (PWM) waveform. Secondly, the microcontroller circuit also simple and easy to control. Therefore, the microcontroller is cheaper than microprocessor.

Beside that, the system build up are using optocoupler to switching the pulse width modulation (PWM) before go throw the gate of Mosfet for inverter circuit. And the application, function or advantage in the circuit is to:

- Monitor high voltage.
- Output voltage sampling for regulation.
- System for control micro for power on/off.
- Ground isolation

## 1.3 SCOPE OF PROJECT

The scope of this project is to develop a gate drives system for single phase AC induction motor. To achieve the objective of the project some of power electronic circuits need to be developed. Firstly, rectifier circuit should be design. The rectifier is used to convert AC supply to DC supply. Secondly inverter circuit should be design in order to re-convert DC supply into AC supply. Furthermore, the AC supply can be a variable frequency controlled through adjusting pulse duty cycle of the PWM signal.

# CHAPTER 2.0

# LITERATURE REVIEW

## 2.1 SINGLE PHASE AC INDUCTION MOTOR CHARACTERISTIC

Induction motor is widely used in many residential, commercial, industrial and utility applications [9]. AC induction motors transform electrical energy into mechanical energy. It can be part of fan or pump, or connected to some other mechanical application such as a winder and conveyor. In this project specification of the motor are single phase AC induction motor 240V 500W. There are three basic parts of the AC induction motor that are rotor, stator and enclosure. Stator and rotor are electrical circuits that are performing electromagnetic. Refer figure 2.1

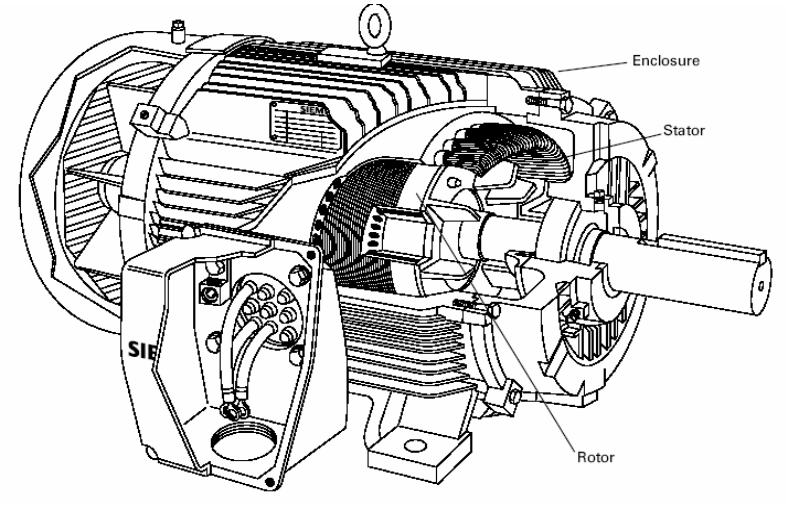


Figure 2.1: Mechanism of AC induction motor

The stator is stationary electrical part of the motor. The core of the stator motor is made up of several hundred thin laminations. These laminations are based on National Electrical Manufactures Associations (NEMA) [9]. Stator laminations are stacked together forming a hollow cylinder and coil of insulated wire are inserted into slot of the stator core. The basic concept of the motor operation is electromagnetism which is each grouping of coil together with the steel it surrounds from electromagnets [9]. The stator windings are connected directly to the power circuit. Refer figure 2.2.

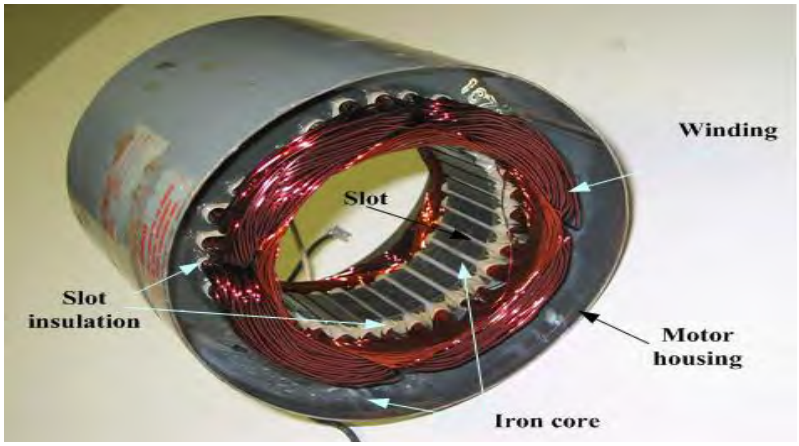


Figure 2.2: Stator of the AC induction motor

The rotor of the AC induction motor is the rotating part of the electromagnetic circuit. The rotor is divided into two types that are squirrel cage and wound rotor. However, the most common type of rotor is squirrel cage. This is because it is low cost, simple, robust and low maintenance. Refer figure 2.3 and 2.4.

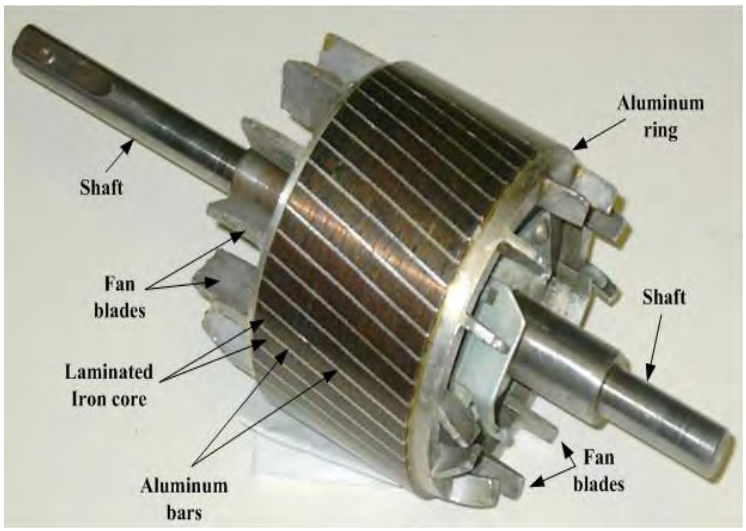


Figure 2.3: The rotor of AC induction motor

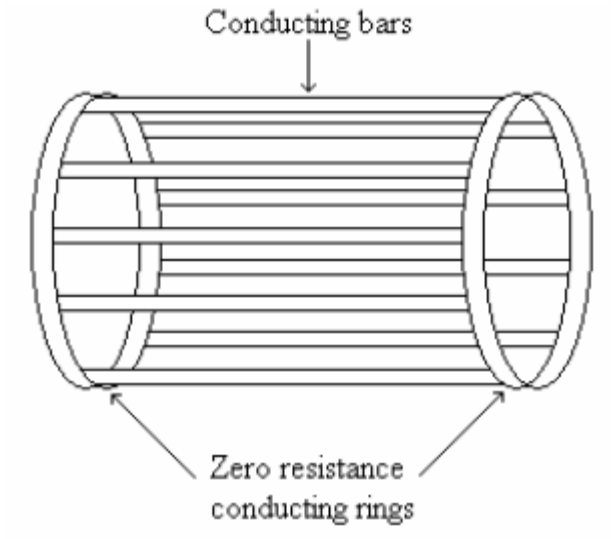


Figure 2.4: Squirrel cage rotor.

The enclosure consist of a frame of yoke and two ends bracket or bearing housing. The stator mounted inside the frame and the rotor fits inside the stator with a slight air gap separating it from the stator. There is no direct physical connection between the rotor and stator. The enclosure also protecting the electrical and operating parts of the motor from harmful effects of the environment in which the motor operates. Refer figure 2.5.

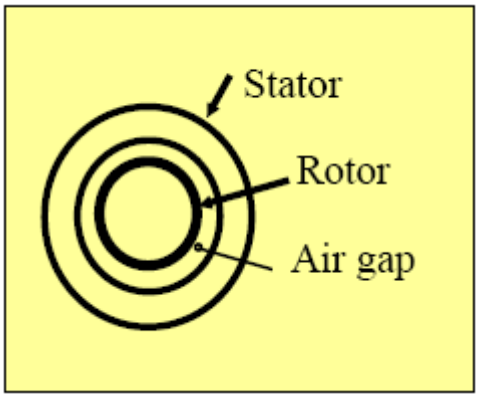


Figure 2.5: Gap between stator and rotor

## 2.2 RECTIFIER CIRCUIT

Rectifier used to convert AC source to DC. There are several rectifiers that can be used such as controlled half wave rectifier, uncontrolled half wave rectifier, controlled full wave bridge rectifier and full wave center tapped bridge. Instead of using half wave rectifier, full wave rectifier is most suitable in high power application such as motor control. In this project, uncontrolled full wave bridge rectifier is used. The purpose of the full wave rectifier is to produce an output that is purely DC, or the purpose may be to produce a voltage or current waveform that has a specification DC component, refer figure 2.6. A diode is a simplest electronics switches. It is uncontrollable in that the on and off condition are determine by voltage and current in the circuit. Full wave bridge rectifier has a R-C filter on the output, refer figure 2.7. the

purpose of the filter is to produce an output voltage which is close to purely DC. Therefore, this DC voltage is used as voltage supply to the inverter circuit.

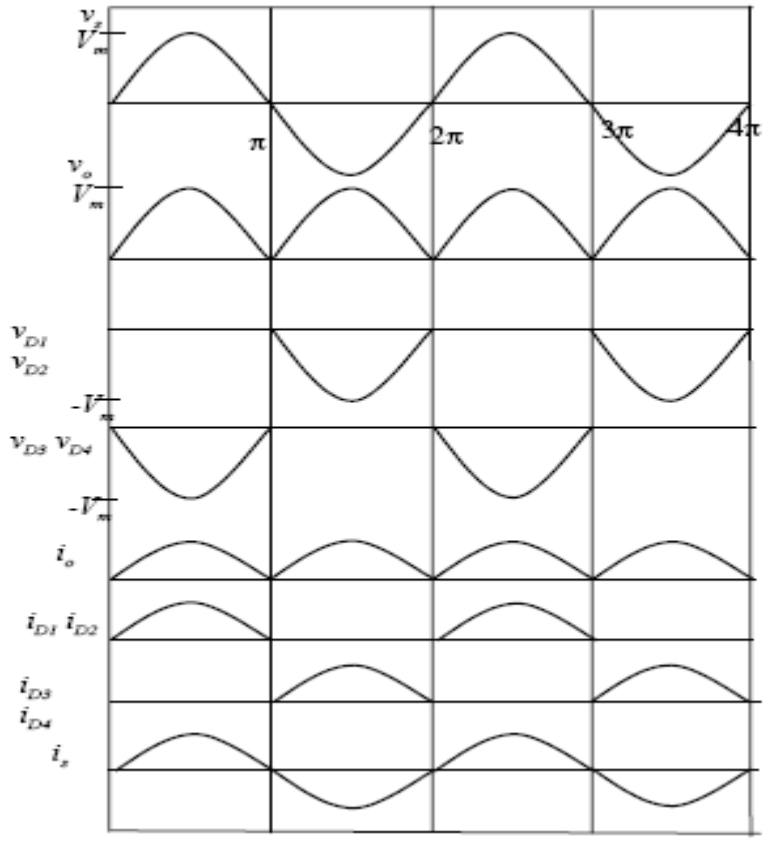


Figure 2.6: The example of output waveform for rectifier

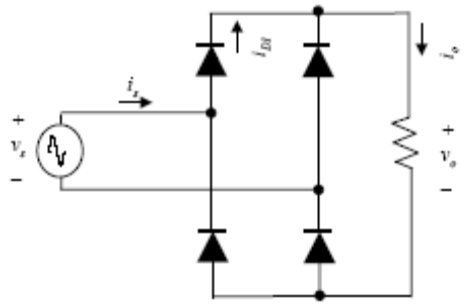

Figure 2.7: Basic circuit for full bridge rectifier