# THE DEVELOPMENT OF CONTROL SCHEME FOR SINGLE PHASE INDUCTION MOTOR

SUMI MURNI ZAKARIA

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Faculty of Electrical & Electronic Engineering
University Malaysia Pahang

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power System) "

Signature : ________________________________________

Name : MR. RAJA MOHD TAUFIKA RAJA ISMAIL

Date : 29 NOVEMBER 2010

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Signature : ______________________________

Author : SUMI MURNI ZAKARIA

Date : 29 NOVEMBER 2010

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# ABSTRACT

The purpose of this study is in electronic scope to develop a control scheme for single phase induction motor application. This project is focus on the AC motor speed control by varying the duty cycle of Pulse Width Modulation (PWM) signal. PWM speed control is desirable due to its high power efficiency compare with another method of speed control like frequency control, current and voltage control. The use of the control systems can add speed variation to the systems. Control schemes should be determined based on the control necessary, the cost and the process. The driver circuit will boosted the PWM signal to drive the MOSFET and thus control the motor. The speed of AC motor is depending on the spectrum of PWM that refer to their duty cycle. This project was able to control the motor speed.

# ABSTRAK

Tujuan projek ini dijalankan untuk membina skop kawalan bagi plikasi satu fasa motor induksi. Projek ini memfokuskn kepada kawalan kelajuan motor AC dengan mengawal PWM signal. Kawalan kelajuan PWM yang diinginkan bergantung kepada ketinggian kuasa effektifannya berbanding methodology kawalan kelajuan seperti kawalan frekuensi, arus and kawalan beza upaya. Kegunaan system kawalan boleh menambah kepelbagaian kelajuan system. Skema kawalan haruslah ditentukan berdasarkan kawalan yang diperlukan, kos dan proses. Litar pemandu akan membantu PWM untuk memandu signal kepada MOSFET seterusnya mengawal kelajuan motor. Kelajuan motor bergantung kepada spectrum PWM yang merujuk kepada duty cycle. Projek ini mampu mengawal kelajuan motor.

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# LIST OF SYMBOLS

| | | |
|---|---|---|
| $C$ | - | Capacitor |
| D | - | Diode |
| DC | - | Direct Current |
| AC | - | Alternating current |
| $f$ | - | Frequency |
| kHz | - | kilo Hertz |
| L | - | Inductor |
| mH | - | mili Henry |
| MHz | - | mega hertz |
| Mosfet | - | Metal Oxide Semiconductor Field EffectTransistor |
| ms | - | mili second |
| R | - | resistor |
| T | - | time |
| V | - | volt |
| μs | - | micro second |
| μF | - | micro Farad |
| Ω | - | Ohm |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

This project is on detailed of control schemes for single phase induction motor application. The AC induction motor is the most commonly used AC motor in industrial applications because of its simplicity. It is because the rotor is a self-contained unit. PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability. The use of the control systems can add speed variation to the systems. Control schemes should be determined based on the control necessary, the cost and the process. Pulse Width Modulation (PWM) techniques is commonly used in a variable frequency drive scheme to control the rotational speed of an induction motor.

## 1.2 Objective of the project

The objectives of this project are

i) To develop a boost converter that convert DC input voltage to higher DC output voltage.

ii) To develop an inverter that convert dc to ac

iii) To control the speed of the single phase induction motor by varying PWM

## 1.3 Scope of the project

This project is developed by using input of 12V battery. Boost converter are used to convert DC to DC and step up the voltage. Then an inverter is used to convert the DC to AC voltage. A single phase induction motor is connected to the end of the inverter.

## 1.4 Problem statement

The induction machine is the most widely used machine in industry and is referred to as the work horse of industry. Induction motor is commonly used because of its simplicity, rugged construction and relatively low manufacturing costs. Single phase induction motor is used for very small commercial application such as buffers. So, it is important to control the motor speed in order to achieve a good production. One of the methods that can be used to control speed of the motor is varying PWM. Manual controller is also not practical in the technology era because it can waste time and cost. Operation cost regarding controller is got attention from industrial field.

## 1.5 Project background

This section will describe the overview of this project

### 1.5 .1 Single phase induction motor

Three-phase motors produce a rotating magnetic field. However, when only single-phase power is available, the rotating magnetic field must be produced using other means. Several methods are commonly used. A common single-phase motor is the shaded-pole motor, and is used in devices requiring low starting torque, such as electric fans or other small household appliances. Single phase motor are manufactured in fractional kilowatt range to be operated in single phase supply and for use in numerous applications like ceiling fans, food mixer, hair drier, portable drills, vacuum cleaners and electric shavers.

### 1.5.2 Pulse Width Modulation

Pulse width modulation (PWM) is a very efficient way of providing intermediate amounts of electrical power between fully on and fully off. A simple power switch with a typical power source provides full power only, when switched on. PWM is a comparatively recent technique, made practical by modern electronic power switches. Pulse width modulation is used to control the frequency and the magnitude of the AC voltage across the load and to reduce the harmonic contents in the output voltage or current. There are number of PWM techniques, but the most common type is the sinusoidal PWM. PWM works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle. PWM of a signal or power source involves the modulation of its duty cycle, to either convey information over a communications channel or control the amount of power sent to a load.

### 1.5.3 Methodology

The first method is simulation circuit using Orcad. The circuit is simulated to get expected output waveform at test points and it is compared to the theory. The second method is constructing the circuit on breadboard. The circuit is tested to get expected result base on theory. The third method is designed a PIC programmed that can control the speed of the single phase induction motor. The 12v lead acid battery is used as a supply. Then the boost converter is use to get the higher output voltage. Then the inverter is use to convert the dc voltage to ac voltage.

## 1.6 Thesis outline

This thesis is divided into six chapters. The content of each chapter is summarized below.

Chapter 1 discusses the overview of the concept of this project, objective of the project and scope of the project.

Chapter 2 describes briefly the hardware components used in this project, including their description of operation and article review of the project.

Chapter 3 focuses on the methodology of this project which includes the generation of the power supply, generation of PWM waveform and full diagram of the circuit.

Chapter 4 elaborates in detailed about the designing step of boost converter, pulse width modulation generation and PI controller.

Chapter 5 focuses on the results obtain from the simulation design using Orcad and the results that obtain from hardware design.

Chapter 6 describes the conclusion, the future recommendation and the costing and commercialization of the project.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter will describes in details about induction motor, lead acid battery, boost converter, inverter, PI controller and Pulse Width Modulation. All those elements are use to develop this project.

## 2.2 Induction motor

An induction motor (or asynchronous motor or squirrel-cage motor) is a type of alternating current motor where power is supplied to the rotor by means of electromagnetic induction. An electric motor converts electrical power to mechanical power in its rotor (rotating part). In an induction motor, both the stator and the rotor windings carry alternating currents. The alternating current is supplied to the stator directly and to the rotor by induction and hence the name induction machines [1]. Induction motors are often reliable and maintenance is often the first choice when failure or preventing failure [2].

### 2.2.1 Single Phase Induction motor

A motor that operates on a single-phase source is called a single phase induction motor. A single phase induction motor requires only one single phase winding to keep the motor running [3]. The single phase motor needs to have high starting torque as well as high efficiency. But there is trade-off between efficiency and starting torque. Most single-phase induction motors are built in the fractional-horsepower range and are used in heating, cooling, and ventilating systems [4]. For small motors of a few watts the start rotation is done by means of a single turn of heavy copper wire around one corner of the pole.

#### 2.2.1.1 Shaded pole motors

Shaded pole motors used as a shaded stator pole for starting. Shading the stator pole is the simplest method used to start a single phase motor. Shaded-pole motor are commonly 1/20 HP or less and have low starting torque. Common applications of shaded pole motors include small cooling fans found in computers and home entertainment centers. The shaded pole is normally a solid single turn of cooper wire placed around a potion of the main laminations [5].

#### 2.2.1.2 Split-phase motors

A split-phase motor is a single phase motor that includes a running winding (main winding) and a starting winding (auxiliary winding). Split phase motors are AC motors of fractional horsepower, usually 1/20 HP to 1/3 HP. Split phase motors are commonly used to operate washing machines, oil burners and small pumps and blowers. A split phase motor has rotating part (rotor), a stationary part consisting of the running winding and starting winding (stator) and a centrifugal switch that is located inside the motor to disconnect the starting winding at approximately 60% to 80% of full load of speed. A continuous-duty motor must operate at full load or 1 hour or more in a 24 hour period. [5]

#### 2.2.1.3 Capacitor-phase motors

A capacitor motor is a single phase motor that includes a capacitor in addition to the running and starting windings. Capacitor motor sizes range from 1/8 HP to 10 HP. Capacitor motor are used to operate refrigerators, compressor, washing machines and air conditioners. The construction of a capacitor motor is similar to that of a split phase motor except that in a capacitor motor, a capacitor is connected in series with the starting winding. The addition of a capacitor in the starting winding gives a capacitor motor more torque than a split-phase motor. The three types of capacitor motors are capacitor start, capacitor run and capacitor start and run motors [5].

## 2.3 Lead Acid Battery

Lead-acid batteries, invented in 1859 by French physicist Gaston Planté, are the oldest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors.

Lead acid batteries designed for starting automotive engines are not designed for deep discharge. They have a large number of thin plates designed for maximum surface area, and therefore maximum current output, but which can easily be damaged by deep discharge. Repeated deep discharges will result in capacity loss and ultimately in premature failure, as the electrodes disintegrate due to mechanical stresses that arise from cycling. A common misconception is that starting batteries should always be kept on float charge. In reality, this practice will encourage corrosion in the electrodes and result in premature failure. Starting batteries should be kept open circuit but charged regularly (at least once every two weeks) to prevent sulfation.

Lead-acid batteries are the oldest type of rechargeable battery. The lead-acid battery has many advantages over other rechargeable batteries [6]. The most important for cavers being: fairly high power to weight ratio; low cost; high electrical efficiency (important where lamps are being recharged from vehicle batteries) flat discharge voltage characteristics; simple self-service charging capability; and finally, the electrolyte is far less dangerous than that used in alkali batteries, although the acid will affect the strength of nylon equipment. On the other hand, lead-acid batteries are perhaps more susceptible to incorrect charging than alkali types, though if the right method is used overcharging cannot occur and reliable performance should be obtained [7]. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors.

## 2.4 Boost converter

In this project, a boost converter will use to increase the value of DC input voltage. A boost converter is a DC to DC converter with an output voltage greater than the source voltage. Since power ($P = VI$) must be conserved, the output current is lower than the source current. It is a class of switching-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple. Boost converters can increase the voltage and reduce the number of cells.

### 2.4.1 Operating principle

The key principle that drives the boost converter is the tendency of an inductor to resist changes in current. When being charged it acts as a load and absorbs energy (somewhat like a resistor), when being discharged, it acts as an energy source (somewhat like a battery).

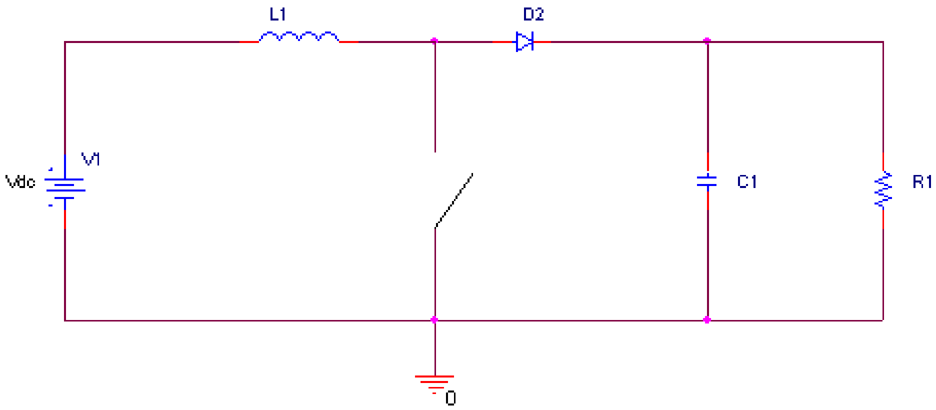
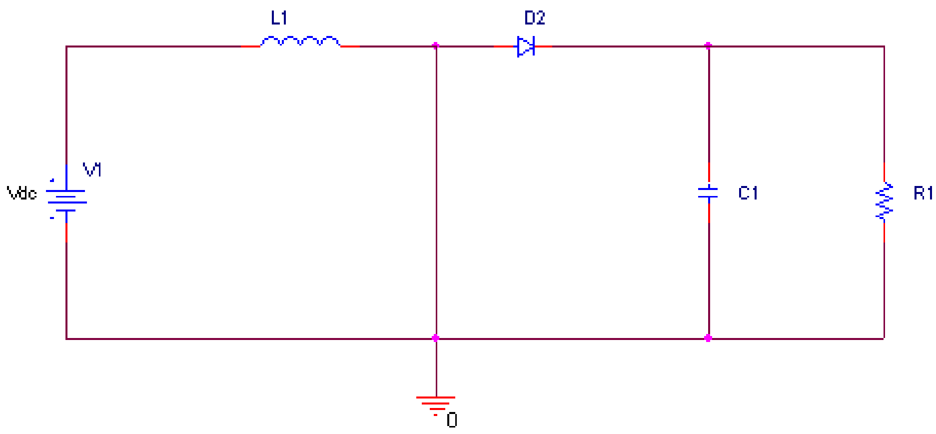
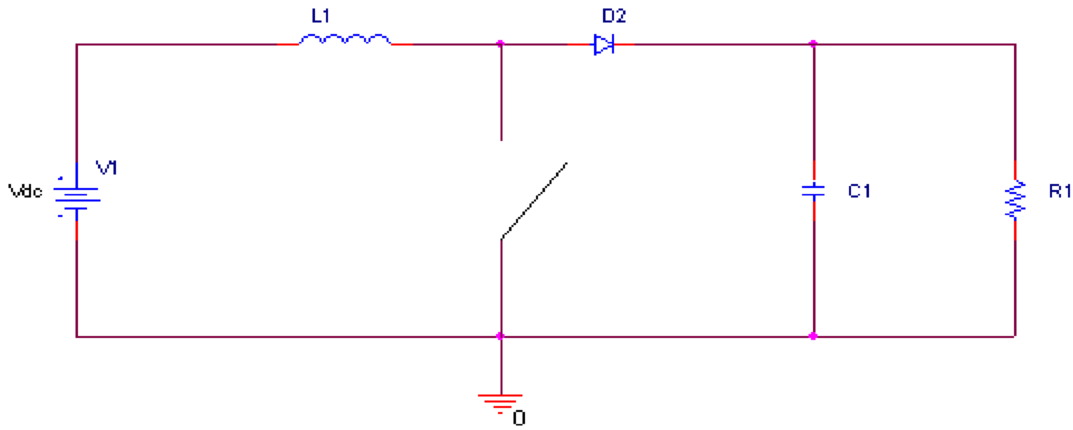



**Figure 2.1**: Basic boost converter schematic

Figure 2.1 shows the basic schematic for boost converter. The switch is typically a MOSFET, IGBT, or BJT.




**(a)**




**(b)**

**Figure 2.2:** (a) ON state, (b) OFF state

In the On state as in Figure 2.2 (a), the switch is closed, resulting in an increase the inductor current. The inductor current increase during the ON state is given by:

$$\Delta I \;=\; \frac{(\qquad\qquad)}{\qquad} \; x + T \qquad (1)$$

The quantity $\Delta I$ is the inductor ripple current. During this period, all of the output load current is supply by output capacitor C1. When the switch is open as in Figure 2.2 (b), the only path offered to inductor is through the flyback diode D2, the capacitor C1 and the load R1. This result in transferring the energy accumulated during the on-state into the capacitor. During OFF state, the voltage across inductor is constant and equal to $( V + V + I \; R ) - V$ . The inductor current decrease during the OFF state is given by:

$$\Delta I \;=\; \frac{(\qquad\qquad)}{\qquad} \; x + T \qquad (2)$$

The quantity of the $\Delta I$ is also the inductor ripple current.

## 2.5 Power MOSFET

MOSFET is known as the metal-oxide-semiconductor field-effect. Transistor is a device used to amplify or switch electronic signals. There are two type of MOSFET which is n type n p type.

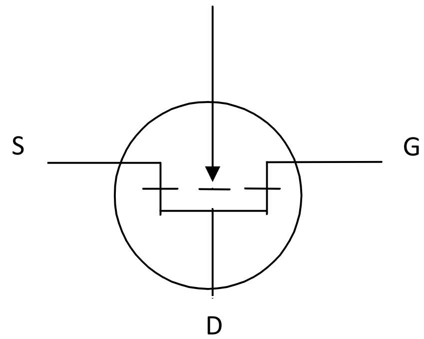



**Figure 2.3** MOSFET configuration

Figure 2.3 shows the basic configuration of power MOSFET. It shows that when electrical bias applied to the gate G, no current can flow in either direction in the gate because there will always be a blocking p-n junction.

### 2.5 .1 Advantages of MOSFET

MOSFET has more advantages than other switching devices. Some of the advantages of MOSFET are listed below.

(i) Low gate signal power requirement. No gate current can flow into the gate after the small gate oxide capacitance has been charged.

(ii) Fast switching speeds because the channel opens very fast when electron starts to flow.