DEVELOPMENT OF CONTROL SHCEME FOR DC MOTOR SPEED CONTROL APPLICATIONS

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"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)"

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ABSTRACT

Nowadays, DC motors plays a vital role in most of the industrial areas, it can be seen in most of the electronic devices. The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. In this project, the power converter for DC motor application is developed. One of the most common methods is by using PWM wave to control the speed of the motor. Therefore, to provide the required power to the motor, SPMS is used to supply the DC motor from AC power supply. Rectifier which converted AC/DC and buck converter are combined which output can be supplied to the DC motor. The SMPS which supplies the DC motor is developed and the output is controlled by using PWM. TL494 is used to generate the PWM wave which can be varied in duty ratio. In the end of this project, the motor speed will satisfied the desired speed control as expected.

ABSTRAK

Pada masa kini, DC motor memainkan peranan penting didalam kawasan perindustrian yang dapat dilihat penggunanaannya untuk peralatan elektronik. Tujuan mengawal kelajuan motor adalah bagi mengambil isyarat yang mewakili kelajuan yang diminta dan untuk mengawal motor pada kelajuan yang telah ditetapkan. Melalui projek ini, penukar kuasa untuk aplikasi motor DC telah dihasilkan. Salah satu cara yang sering digunakan adalah melalui gelombang PWM untuk mengawal kelajuan motor. Walau bagaimanapun, untuk menghasilkan kuasa yang diperlukan oleh motor, SPMS digunakan untuk memberi kuasa kepada motor AC dari motor DC. Perata arus (Rectifier) yang mengubah AC/DC dan *'buck converter'* digabungkan dimana keluaran dapat dibekalkan kepada motor DC. SMPS yang membekalkan motor DC telah dikembangkan dan keluaran dikawal oleh PWM. PIC microcontroller digunakan untuk menghasilkan gelombang PWM yang dapat dikawal melalui perbandingan bebas (duty ratio). Di akhir projek ini, kelajuan motor akan memenuhi kelajuan yang ditetapkan.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

	=	Sawtooth voltage
	=	Dc input voltage
	=	Average output voltage
	=	Settling time
	=	Inductor/positive voltage
	=	Input power
	=	Output power
	=	Resistor
	=	Inductor
	=	Capacitor
	=	Inductor current
	=	Duty ratio
	=	Centimetre
	=	Silicon
	=	Silicon dioxide
	=	Oscillator frequency
	=	Hertz
	=	Timing capacitor
	=	milivolt
	=	rotation per minute
	=	Pulse width modulation

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will explain the objective of the project, scope of the project, problem statement and the project background. In this introduction section the review of full wave rectifier, buck converter and pulse width modulation (PWM) control will be explained. At the end of chapter 1 the thesis outline is briefly describe.

1.2 Background

Nowadays, the direct current (DC) motor is a device that is used through many industries in order to convert electrical energy into mechanical energy. Industrial machinery is often driven by electric motors that have provisions for speed adjustment. Such motors are simply larger, more powerful versions of those driving familiar appliances such as food blenders or electric drills. These motors normally operate at a fixed speed. If speed control is required, then the controller is called an adjustable speed drive or a variable speed controller.

The speed of a DC motor needs to be controlled by a circuit driver, in order to cater to the users' needs. Basically, it should be able to vary the speed from minimum speed to maximum speed. The voltage must also be limited to 24 Vdc, which is the maximum voltage of the motor itself.

1.3 Objective of the Project

The objectives of the project are as follows:

(i) To develop rectifier to rectify 230 Vac to 24 Vdc

(ii) To develop buck converter that produces dc output voltage that can be varied from 0 Vdc to 24 Vdc

(iii) To control dc motor speed by varying PWM

1.4 Scope of the Project

This project is developed by using input of 240 Vac from TNB. To control and vary the output voltage of power supply, the PWM control technique is used. At the end of the buck converter output DC voltage can be produce in the range of 0 – 24 V. Then a DC motor is connected to the buck converter output to vary the speed.

1.5 Problem Statement

DC Motor is widely used in speed control system which needs high control requirements. So, it is crucial to control the motor speed in order to achieve good production. One of the most common methods to drive a dc motor is by using PWM signals with respect to the motor input voltage.

1.6 Project Background

This section will describe the overview of Pulse Width Modulator (PWM) and the methodology to develop this project. The methodology will be described by using the block diagram.

1.6.1 Overview of Pulse Width Modulator

Pulse Width Modulator (PWM) 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 a number of PWM techniques, but the most common type is the sinusoidal PWM [7].

1.6.2 Methodology of the Project

In the research of this project, the 230 Vac power supply is step down by the transformer. Then, the ac voltage is rectified to produce pure dc voltage. Dc voltage is then feed as input of buck converter. MOSFET is used as the power switch of this project. The output voltage of the converter is then varied by using pulse width modulation control which varies the duty cycle of the switch.

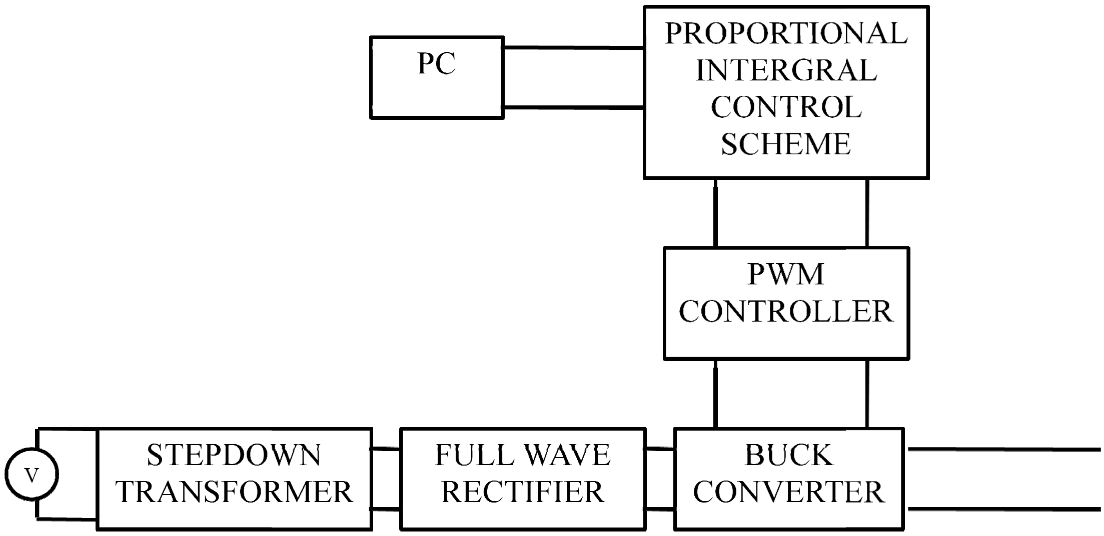


Figure 1.1: Block diagram of the project

1.7 Thesis Outline

This thesis was divided into 6 chapters which the content of each chapter was summarized as below.

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

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

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

Chapter 4 elaborated in detailed about the designing step of buck converter and the PI controller design.

Chapter 5 focused on the result obtained from the simulation designed by using MatLab and the result obtained from hardware design.

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

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter includes the study of different types of DC motors. In this chapter will explain in detail the operation of pulse width modulation control, full wave rectifier and buck converter. Besides, all the circuit diagram and element that had been used to develop this project will be review in detail.

2.2 DC Motor

There are several types of DC motors that are available. Their advantages, disadvantages, and other basic information are listed below in the Table 2.1. In this project, I had chose DC permanent magnet servo motor which is small, compact and easy to find. This type of motor is inexpensive to get. However, this type of DC motor is generally small and cannot vary the magnetic field strength.

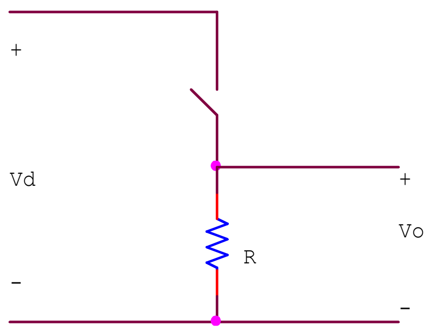
Table 2.1 Advantages and disadvantages of various types of DC motor.

Type	Advantages	Disadvantages
Stepper Motor	Very precise speed and position control. High Torque at low speed.	Expensive and hard to find. Require a switching control circuit
DC Motor w/field coil	Wide range of speeds and torques. More powerful than permanent magnet motors	Require more current than permanent magnet motors, since field coil must be energized. Generally heavier than permanent magnet motors. More difficult to obtain.
DC permanent magnet motor	Small, compact, and easy to find. Very inexpensive	Generally small. Cannot vary magnetic field strength.
Gasoline (small two stroke)	Very high power/weight ratio. Provide Extremely high torque. No batteries required.	Expensive, loud, difficult to mount, very high vibration.

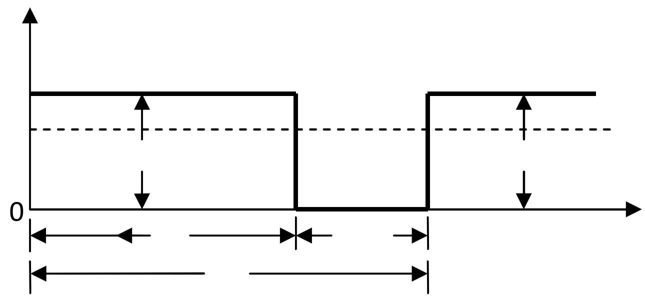
2.3 Pulse Width Modulator (PWM)

In principle, all modulation schemes aim to create trains of switched pulses which have the same fundamental volt-second average (i.e., the integral of the voltage waveform over time) as a target reference waveform at any instant. The major difficulty from these trains of switched pulses is that they also contain unwanted harmonic components which should be minimized. Hence for any PWM scheme, a primary objective can be identified which is to calculate the converter switch ON times which create the desired (low frequency) target output voltage or current [2]. Having satisfied this primary objective, the secondary objective for a PWM strategy is to determine the most effective way of arranging the switching processes to minimize unwanted harmonic distortion, switching losses or any other specified performance criterion.

In dc-dc converter, the average dc output voltage must be controlled to equal a desired level, though the input voltage and the output load may fluctuate [3]. Switch mode dc-dc converters utilize one or more switches to transform dc form one level to another. In a dc-dc converter with a given input voltage, the average output voltage is controlled by controlling the switch ON and OFF durations (and) [2, 3]. To illustrate the switched mode conversion concept, consider a basic dc-dc converter shown in figure 2.1a. The average value of the output voltage in figure 2.1b depends on and . One of the methods for controlling the output voltage employs switching at a constant frequency hence, a constant switching time period, = + and adjusting the ON duration of the switch to control the average output voltage [3]. In this method, called pulse width modulation (PWM) switching, the switch duty ratio, D, which is defined as the ration of the ON duration to the switching time period, is varied [3, 4, 5].



(a)



(b)

Figure 2.1: Switch mode dc-dc conversion: (a) Basic dc-dc converter; (b) The average value of the output voltage

In the PWM switching at a constant switching frequency, the switch control signal which controls the state (ON or OFF) of the switch is generated by comparing a signal level control voltage, with a repetitive waveform as shown in figure 2.2b. The control voltage signal generally is obtained by amplifying the error or the difference between the actual output voltage and its desired value. The frequency of repetitive waveform with a constant peak which is shown to be a saw tooth, establish the switching frequency. This frequency is keep constant in a PWM control and is chosen to be on a few kilohertz to a few hundred kilohertz range [3]. When the amplified error signal, which varies very slowly with time relative to the switching frequency, is greater than the saw tooth waveform, the switch control signal becomes high causing the witch to turn ON. Otherwise, the switch is OFF.

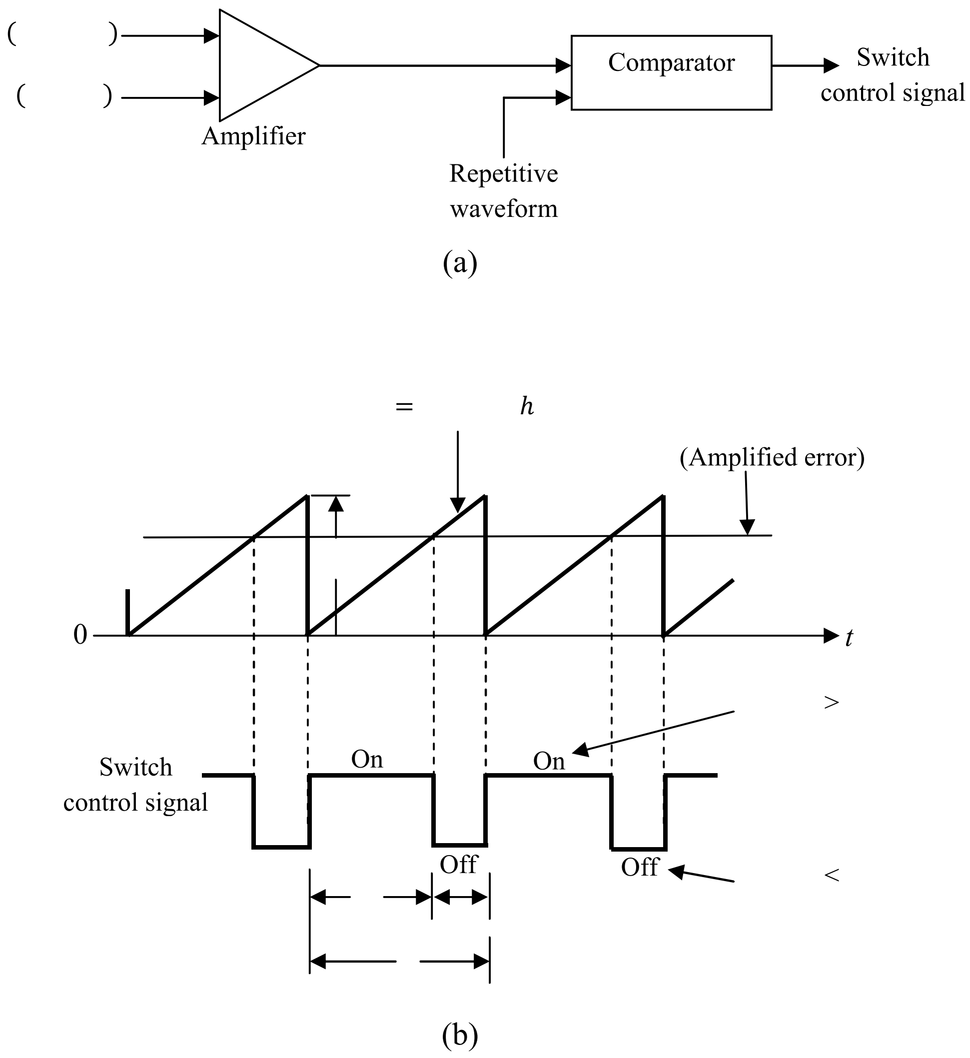


Figure 2.2: Pulse Width Modulator: (a) block diagram; (b) comparator signals

In terms of and the peak of the saw tooth waveform in figure 2.2b, the switch duty ration can be expresses as;

$$= — = ——— \quad (2.1)$$

The dc-dc converters can have two distinct modes of operation:

(i) Continuous current conduction
(ii) Discontinuous current conduction

In practice, a converter may operate in both modes, which have significantly different characteristics [3, 5]. Therefore, a converter and its control should be designed based on both modes of operation.

2.4 Full Wave Rectifier

DC voltage and current are required for electronic devices, hence, is necessary to covert AC into DC by a process called rectification. There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC [6]. The objective of a full wave rectifier is to produce a voltage or current that is purely DC or has some specified DC component [4]. Rectification of AC voltages and currents is accomplished by means of diodes [3].

During the positive half-cycle, shown in red, the top end of the transformer winding is positive with respect to the bottom half. Therefore, the transformer pushes electrons from its bottom end, through D3 which is forward biased, and through the load resistor in the direction shown by the red arrows. Electrons then continue through the forward-biased D2, and from there to the top of the transformer winding. This forms a complete circuit, so current can indeed flow. At the same time, D1 and D4 are reverse biased, so they do not conduct any current.

During the negative half-cycle, the top end of the transformer winding is negative. Now, D1 and D4 are forward biased, and D2 and D3 are reverse biased. Therefore, electrons move through D1, the resistor, and D4 in the direction shown by the blue arrows. As with the positive half-cycle, electrons move through the resistor from left to right.