"This report attached here was prepared by Hisham B. Abd Aziz in partial fulfillment for the Bachelor Degree Of Electronic Engineering (Computer Electronic) with honors is here by approved. ."

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STEPPER MOTOR CONTROLLER USING PIC

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" I here by admit that the paper is my own work except some of the parts which have been cited accordingly."

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I dedicate this book to my mother, family members
and last but not least, to all my KUTKM lecturers and friends.

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This study could never have been completed without the help and support of many individuals. I wish to express my most sincere gratitude to all of the people who helped me to make this project successful especially to my supervisor, Pn. Siti Khadijah Binti Idris @ Othman for providing the excellent guidance, concern and informative discussions regarding to my project. Finally to my beloved family members for their unconditional love, support and patience and at last to my friends who gave me support and opinion to make my project successful.

ABSTRACT

There are different kinds of stepper motors in the market, such as bipolar motor and unipolar motor. We have to choose the correct stepper motor according to our specification due to process that we need to run. The controller of the motor is design by using PIC (Peripheral Interface Controller) whereby it will control by using switch. The PIC that I'm going to use is chip PIC16F84A or PIC16F877A. This project is featured with different kind of automatic control mode that will programmed by using the MPLAB software and burn in the chip which will identified the way of turn, stop command and also the control of the speed. To simplified the design, I'm using a parallel connector, which is connected between the computer interface and the PIC. I have done many types of analysis to the stepper motor to identify the power, the efficiency and speed of the motor. To complete the project I have collected data on speed, complete turn of the motor, status and motor simulation.

ABSTRAK

Terdapat pelbagai jenis motor pelangkah di pasaran antaranya motor pelangkah bipolar dan unipolar. Pemilihan pemacu motor pelangkah yang bersesuaian dengan jenis motor perlu dilakukan untuk meningkatkan lagi kecekapan sesuatu kerja. Sistem Kawalan Mikrokomputer ke atas motor pelangkah ini (Stepper Motor Controller) direka bentuk menggunakan PIC (Peripheral Interface Controller) yang dikawal oleh pengguna melalui suis. Untuk projek ini, jenis kawalan mikro yang akan digunakan ialah dari keluaran Microchip jenis PIC16F84A atau PIC16F877A. Projek ini mempunyai mod kawalan automatik yang telah diaturcarakan menggunakan perisian MPLAB dan diprogramkan pada PIC dengan pelbagai fungsi seperti arah putaran, berhenti serta kelajuan motor. Bagi memudahkan lagi reka bentuk, seselari komputer (PRINTER PORT) tersebut digunakan untuk mengantara muka komputer dengan PIC manakala litar pemacu motor yang telah direka bentuk khas akan digunakan. Analisis akan dibuat pada motor pelangkah dari pelbagai faktor termasuklah penggunaan kuasa, arus yang lebih efisien, kelajuan motor dan tujahan. Data-data kawalan seperti laju , arah putaran, bilangan langkah, status dan simulasi pelangkahan motor digunakan untuk melengkapkan projek ini.

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LIST OF ABBREVIATION

PIC	-	Peripheral Interface Controller
PLC	-	Programmable Logic Controller
DC	-	Direct Current
PM	-	Permanent Magnet
VR	-	Variable Reluctance
PWM	-	Pulse Width Modulation
ZIF	-	Zero Insertion Force Socket
PCB	-	Printed Circuit Board
Steps/rev	-	Steps/revolution
W	-	Watt

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CHAPTER I

INTRODUCTION

1.1 OBJECTIVES

The objective of this project are to design a circuit stepper motor using PIC (Peripheral Interface Controller) by doing analysis on the power, the efficiency and speed of the motor for more efficient. Also to design to make position and speed control very easy.

1.2 SCOPE OF WORK

To upgrade the efficiency of the stepper motor, I have to design a circuit by doing analysis on the power, the efficiency and speed of the motor. The usage of chip, PIC16F84A or PIC16F877A, is depends on the features of the stepper motor to increase the usage efficiency by controlling using the software (Visual basic).

1.3 PROBLEM STATEMENT

i. How to increase the motor stepper speed. This happen because the lacking current of motor stepper and the output power which is low, which reaches the maximum speed cause the speed deficient

ii. How to design motor drive circuit. This is because motor drive stepper are complex compare to others motor drive are designing drive motor circuit is important to determine the efficiency.

1.4 OUTLINE OF THE PROJECT

The introduction chapter covers the background and motivation to the problem as well as the system requirements and a proposed system overview. The outline of the rest of the report is as follows. The Project objective explains a choice to develop new methods for design a driver circuit stepper motor using PIC (Peripheral Interface Controller) by doing analysis on the power, the efficiency and speed of the motor for more efficient. The Scope project gives detailed descriptions of the functionality of the implemented software system.

The problem statements cover the disadvantage of review system and the advantages develop this method. In literature review explains the main ideas of the approach taken here as well as a frame of conditions and potential problems to which the system will be adapted. A description of the structure of the implemented prototype with details of the stepper motor device, PIC chip and the method chosen for upgrade the efficiency of the stepper motor is also found in chapter Methodology. In experiments and simulation results the results from a validation process of the performance of the system is presented. A discussion and conclusions about the performance and limitations of the developed system is found in discussion and conclusions at the end.

CHAPTER II

LITERATURE STUDY

2.1 INTRODUCTION

A stepper motor is a marvel in simplicity. It has no brushes or contacts and it is a synchronous motor with the magnetic field electronically switched to rotate the armature magnet. The essential function of a stepper motor is to translate switching excitation changes into precisely defined increments of rotor position. A stepper motor can be viewed as an electric motor without commutators.

Typically, all the windings in the motor are part of the stator, and the rotor is either a permanent magnet, or in the case of variable reluctance motors, a toothed block of some magnetically soft material. A stepping motor system consists of three basic elements, often combined with some type of user interface (like a host computer or a PLC) as shown in Figure 2.1.

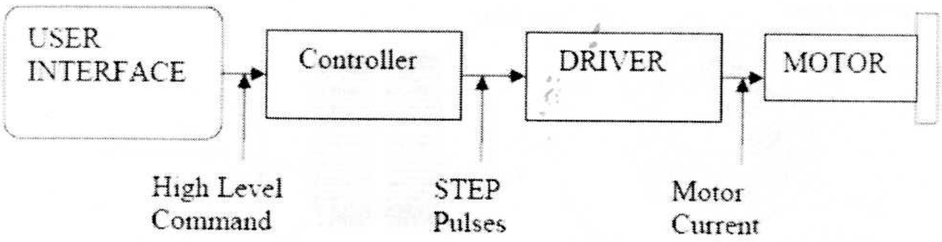

Figure 2.1

The first element, the indexer, is a microprocessor capable of generating pulses and direction signals to the driver. The second element is the driver and converts the indexer command signal into the power necessary to energize the motor winding. The last element is the step motor, which is an electromagnetic device that converts the digital pulses into mechanical shaft rotation.

Advantages of step motors compared to other types of motors are low cost, high reliability, high torque at low speeds and a simple rugged construction that operates in almost any environment. The disadvantages of step motors are resonance effects at low speeds and decreasing torque with increasing speed.

Due to various disadvantages of DC motors in some applications they are increasingly begin replaced by servomotors or stepper motors. Both types of motors offer similar opportunities for precise positioning but they differ in a number of ways. Servomotors require analog feedback control systems of some type while stepper motors can run open loop. When making a choice between them, a number of issues that are application specific must be considered. From a control engineer's perspective, the development of open loop or closed loop control involves modeling.

This chapter will provide a brief overview of the electromechanical behavior of the stepper motor and its principle of operation. Below in Figure 2.2 shows the basic components of a stepper motor.

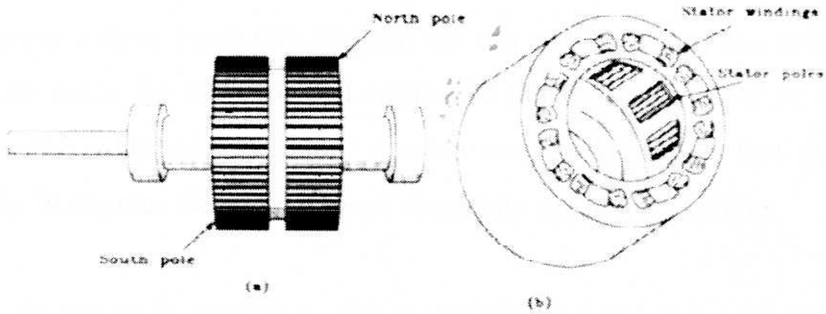

Figure 2.2: Components of a PM Stepper Motor: (a) Rotor; (b) Stator

2.2 THEORY OF OPERATION OF STEPPER MOTORS

Stepper motors provide means for precise positioning and speed control without the use of feedback sensors. The basic operation of the stepper motor allows the shaft to move a precise number of degrees each time a pulse of electricity is sent to the motor. The shaft of the motor moves only the number of degrees that it was designed for when each pulse is delivered. We can control these pulses that are sent and control the positioning and speed. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic field is proportional to the amount of the current sent to the stator and number of turns in the windings.

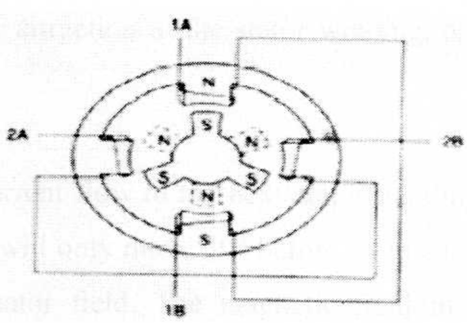

Figure 2.3: Six-Pole Rotors and Four-Pole Stator in a Stepper Motor

The stepper motor uses electromagnetic theory to make the motor shaft turn a precise distance when a pulse of electricity is provided. Like poles of a magnet repel and unlike poles attract. Figure 2.3 shows a typical cross-sectional view of the rotor and stator of a stepper motor. From this diagram we can see that stator has four poles, and the rotor has six poles. So the rotor will require 12 pulses of electricity to move the 12 steps to make one complete revolution. Another way to say this is that the rotor will move precisely 30 degrees for each pulse of electricity the motor receives.

When no power is applied to the motor, the residual magnetism in the rotor magnets will cause the rotor to detent or align one set of its magnetic pole with the magnetic poles of one of the stator magnets. This means that the rotor will have 12 possible detent positions. When the rotor is in a detent position, it will have enough magnetic force to keep the shaft from moving to the next position. This is what makes the rotor feel like it is clicking from one position to the next as you rotate the rotor by hand with no power applied.

When power is applied, it is directed to only one of the stator pairs of windings, which will cause that winding pair to become a magnet. One of the coils for the pair will become the North Pole, and the other will become the South Pole. When this occurs, the stator coil that is the North Pole will attract the closest rotor tooth that has the opposite polarity, and the stator coil that is the South Pole will attract the closest rotor tooth that has the opposite polarity. When current is flowing through these poles, the rotor will now have a much stronger attraction to the stator winding, and the increased torque is called the holding torque.

By changing the current flow to the next stator winding, the magnetic field will be changed 90°. The rotor will only move 30° before its magnetic fields will again align with the change in the stator field. The magnetic field in the stator is continually changed as the rotor moves through the 12 steps to move a total of 360°. Figure 2.4 shows the position of the rotor changing as the current supplied to the stator changes.

In Figure 2.4a we can see that when current is applied to the top and bottom stator windings, they will become a magnet with the top part of the winding being the north pole, and the bottom part of the winding is the south pole. We should notice that this will cause the rotor to move a small amount so that one of its south poles is aligned with the north stator pole (at the top). The opposite end of the rotor pole, which is the North Pole, will align with the south pole of the stator (at the bottom).

A line is placed on the South Pole piece that is located at the 12 o'clock position in Figure 2.4a so that we can follow its movement as current is moved from one stator winding to the next. In Figure 2.4b current has been turned off the top and bottom windings, and current is now applied to the stator windings shown at the right and left sides of the motor. When this occurs, the stator winding at the 3 o'clock position will have the polarity for the south pole of the stator magnet, and the winding at the 9 o'clock position will have the north-pole polarity.

In this condition, the next rotor pole that will be able to align with the stator magnets is the next pole in the clockwise position to the previous pole. This means that the rotor will only need to rotate 30° in the clockwise position for this set of poles to align with the stator poles.

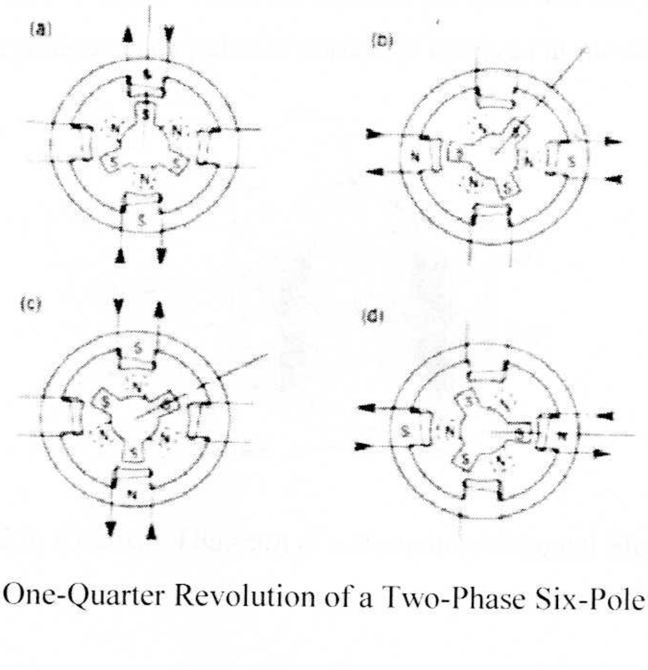

Figure 2.4: One-Quarter Revolution of a Two-Phase Six-Pole Stepper Motor

In Figure 2.4c we can see that the top and bottom stator windings are again energized, but this time the top winding is the south pole of the magnetic field and the bottom winding is the North Pole. This change in magnetic field will cause the rotor to again move 30° in the clockwise position until its poles will align with the top and bottom stator poles. We should notice that the original rotor pole that was at the 12 o'clock position when the motor first started has now moved three steps in the clockwise position. In Figure 2.4d we can see that the two side stator windings are again energized, but this time the winding at the 3 o'clock position is the North Pole.

2.3 TYPES OF STEPPER MOTORS

Three basic types of stepper motors include the permanent magnet motor, the variable reluctance motor, and the hybrid motor, which is combination of previous two.

2.3.1 Permanent Magnet (PM) Stepper Motor

A PM stepper motor operates on the reaction between a permanent-magnet rotor and an electromagnetic field. Figure 2.5 shows a cutaway diagram of a typical permanent magnet stepper motor. The rotor shows that the permanent magnet motor can have multiple rotor windings, which means that the shaft for this type of stepper motor will turn fewer degrees as each pulse of current is received at the stator.

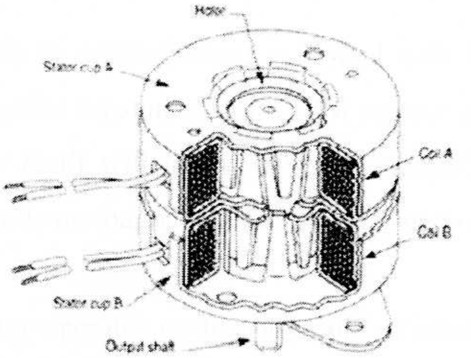

Figure 2.5: Cutaway Diagram of a Permanent Magnet Stepper Motor

For example, if the rotor has 50 teeth and the stator has 8 poles with 5 teeth each (a total of 40 teeth), the stepper motor is able to move 200 distinct steps to make one complete revolution. This means that shaft of the motor will turn 1.8° per step. The main feature of the permanent magnet motor is that a permanent magnet is used for the rotor, which means that no brushes are required.

The drawback of this type of motor is that it has relatively low torque and must be used for low-speed applications. If no power is applied to the windings a small amount of magnetic force is developed between the permanent magnet and the stator. This magnetic force is called a *residual* or *detent torque*. The detent torque can be noticed by turning a stepper motor by hand and is generally about one-tenth of the holding torque. The PM stepper motor has to overcome the detent torque to line up with the stator field when a steady DC signal is applied to the stator winding.

2.3.2 Variable Reluctance Stepper Motor

The variable-reluctance (VR) stepper motor at its core basically differs from the PM stepper in that it has no permanent-magnet rotor and thus no residual torque to hold the rotor at one position when turned off. This means the field strength can be varied. The stator of a variable-reluctance stepper motor has a magnetic core constructed with a stack of steel laminations.

The rotor is made of demagnetized soft steel with teeth and slots, or any other such magnetically permeable substance, unlike PM stepper motors. When the stator coils are energized, the rotor teeth will align with the energized stator poles. In the non-energized condition there is no magnetic flux in the air gap so there is no detent torque.

This type of motor operates on the principle of minimizing the reluctance along the path of the applied magnetic field. By alternating the windings that are energized in the stator, the stator field changes, and the rotor moves to a new position.