PM STEPPER MOTOR CONTROL SYSTEM BY PIC

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DESIGN AND IMPLEMENTATION OF A PM STEPPER MOTOR CONTROL SYSTEM BY A PIC

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"I hereby declare that this report is an original work of my own, except for selected text, summaries and excerpts which are referenced and its source clearly indicated."

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ABSTRAK

Projek ini mempersembahkan sebuah rekaan pengawal motor pelangkah yang menggunakan pengawal mikro untuk mengawal segala pergerakkannya seperti putaran dan kelajuan. Projek ini akhirnya berupaya dikawal oleh sistem konputer, alat pengesan dan butang yang sebagai medan pengawal motor pelangkah tersebut. Kegunaan utama motor pelangkah adalah seperti pemacu cakera, pencetak, robot, peralatan mesin, pemain cakera padat dan sebagainya. Demi mencapai fungsi berikut, biasanya sistem memerlukan satu pengawal mikro untuk menghasilkan denyutan digital menggerakkan motor pelangkah dan menjana frekuensi menentu kelajuan putaran motor. Pada masa kini, terdapat banyak jenis tangan robot yang memakai motor pelangkah sebagai pergerakkanya disebabkan kejituannya untuk mencapai satu kedudukan adalah tepat sekali. Selain daripada itu, motor pelangkah juga banyak digunakan dalam industri sebagai pengangkut kerana harga untuk satu motor pelangkah yang lebih murah.

ABSTRACT

This project represents the design and implementation of a stepper motor control system that is conceive to using a microcontroller – Microchip, Peripheral Interface Controller (PIC16F84A) to manipulated the operation of the motor such as speed and rotation and lastly it will be able to control the operation through the computer, manual and sensor. Preliminary application stepper motor is for disc drivers, printers, robots, machine tools, CD players, plotters and so on. To achieve this, basically the system needs a microcontroller to generate digital signal or pulse to move the stepper motor. The velocity of the motor is depended with the period of the signal generated. Nowadays, many kinds of robot arm are applying stepper motor as its movement motor because it can make high accuracy to reach a position. Besides, the stepper motor also applied in many industries area to use as conveyor because the stepper motor is the cheapest.

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CHAPTER I

INTRODUCTION

1.1 An Overview

The Stepper Motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. Advantages of stepper motors are low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment. The main disadvantages in using a step motor is the resonance effect often exhibited at low speeds and decreasing torque with increasing speed.

There are many kind of stepper motors in the market such as Unipolar type, Bipolar type, Single-phase type, Multi-phase type and etc. On this project it was used the 2-phase Unipolar PM type stepper motor. The controller is a microprocessor based and capable of generating step pulses as direction signals for the driver. In addition, the controller is typically required to perform many other sophisticated command functions such like rotational control and the speed control. The driver responsible converts the indexer command signals into the power necessary to energize the motor windings.

There are numerous types of drivers with different current/amperage ratings and construction technology. Not all drivers are suitable to run all motors, so when designing a Stepper Motor Controller the driver selection process is critical. Below had list up some of the controller which describes its specification and price according to Farnell catalog 2005/06.

Image			
Brand	SAIA-BURGESS	SANYO DENKI	MCLENNAN
Manufacturer Part #	SE2	PMM-MD-23221-10	MSE570 EVO 2
Description	CONTROLLER, STEPPER 0.5A	CONTROLLER, STEPPER 4 OPTION • Current, RMS max: 3A • Depth, external: 83mm • Length / Height, external: 43mm • Voltage, output max: 36V dc • Voltage, output min: 24V dc • Voltage, supply: 5V dc • Width, external: 57mm	CONTROLLER, STEPPER 3A • Length / Height, external:100mm • Voltage, supply max:42V • Voltage, supply min:15V • Width, external:60mm • Length, overall:160mm • Output current per phase (max):3.5A • Output current per phase (min):0.5A • Output current ranges:1 - 3 Amps • Power, output:12W
Price Per Unit #	RM176.83	RM1,132.21	RM914.89

Image			
Brand	ASTROSYN	UNBRANDED	UNBRANDED
Manufacturer Part #	XPVP134	GSM4+PSU2	GSM5+PSU5
Description	CONTROLLER, STEPPER 2A • Current, output max: 2A • Depth, external: 160mm • Frequency, clock max: 30kHz • Length / Height, external: 17mm • Voltage, supply max: 30V • Voltage, supply min: 15V • Width, external: 100mm	STEPPER MOTOR DRIVE, 1.5A • Current, full load: 1.5A • Current, output max: 1.5A • Depth, external: 150mm • Length / Height, external: 35mm • Voltage, output max: 40V dc • Voltage, output min: 250mA @ 12V dc • Voltage, supply: 250V • Width, external: 100mm	STEPPER MOTOR DRIVE, 5A • Current, load:5A • Current, output max:250mA • Depth, external:210mm • Length / Height, external:75mm • Voltage, output max:80V dc • Voltage, output min:12V dc • Voltage, supply:250V • Width, external:100mm
Price Per Unit #	RM225.64	RM1,695.56	RM2,811.51

Figure 1.1: Farnell Catalog 2005/06

1.2 Objective

The objective of this project is to design an electronic controller to control 2-phase Unipolar PM type stepper motor. The peripheral integrated circuit (PIC16F84A) was used as a microprocessor to generated step pulses for the stepper motor. In general, the speed and rotational of the stepper motor is depend to the step pulses character. Therefore, the controller will be able to manipulate the speed and rotational of the motor. Lastly, it includes the computer I/O port, manual and sensor connection part to let the user control the stepper motor by easily. For this entire project, it concerned to the low cost in manufacture and maximizes the best performance.

1.3 Scope of Work

In this project had include consideration to the selection of stepper motor because different diameter of each stepper motor will needed different voltage to charge the coil. Inside the controller had prepared several rotation control part, such as by manual, digital and sensor to let the user easy to control the rotational of the stepper motor based on their prefer. For the digital part, a parallel port was connects between the controller and computer and it applied software were design by Visual Basic display at the screen to allow user control the stepper motor. The programming for the PIC was write in assembly language by MPLab and convert to hex code and them it was program into the PIC by JDM programmer.

CHAPTER II

LITERATURE STUDIES

2.1 Stepper Motor

In this chapter will give a brief review about the characteristic of the PM Stepper Motor, functional of the Microcontroller and implementation of the PC interfacing to a microcontroller. This is because all of that are needed to apply into the project. Initially, because of this project at last is attended to the operation of the Stepper Motor, so it is important to comprehend the motor specification in detail.

2.1.1 Introduction

Motion Control, in electronic terms, means to accurately control the movement of an object based on speed, distance, load, inertia or a combination of all these factors. There are numerous types of motion control systems, including; Stepper Motor, Linear Step Motor, DC Brush, Brushless, Servo, Brushless Servo and more.

In Theory, a Stepper motor is a marvel in simplicity. It has no brushes, or contacts. Basically it's a synchronous motor with the magnetic field electronically switched to rotate the armature magnet around. A Stepping Motor System consists of three basic elements, often combined with some type of user interface (Host Computer, PLC or Dumb Terminal):

1. The Indexer (or Controller) is a microprocessor capable of generating step pulses and direction signals for the driver. In addition, the indexer is typically required to perform many other sophisticated command functions.

2. The Driver (or Amplifier) converts the indexer command signals into the power necessary to energize the motor windings. There are numerous types of drivers, with different current/amperage ratings and construction technology. Not all drivers are suitable to run all motors, so when designing a Motion Control System the driver selection process is critical.

3. The Step Motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation.

The maximum speed of a stepper motor was determined by how long the voltage charges the coil.

2.1.2 Operation Principle

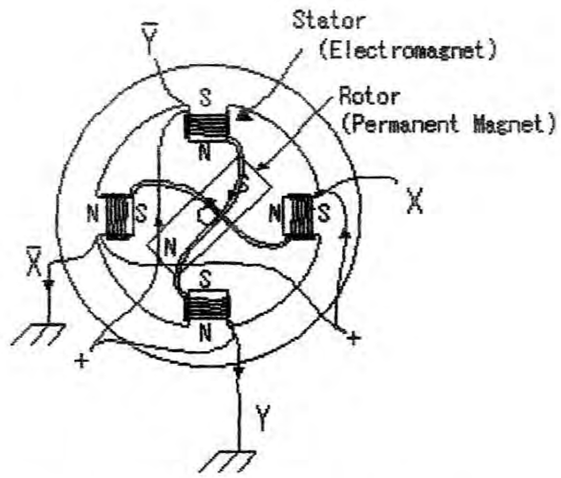
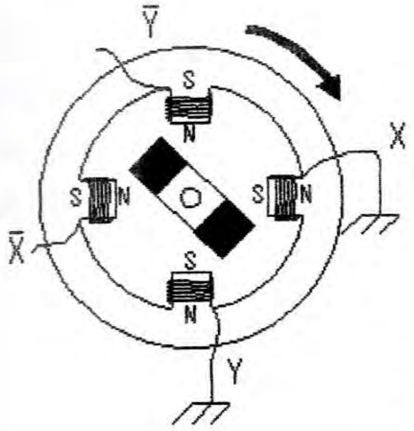


Figure 2.1: Four poles of PM stepper motor

In the PM type stepper motor, a permanent magnet is used for rotor and coils are put on stator. The stepper motor model which has 4-poles is shown in the Figure 2.1 above. In case of this motor, step angle of the rotor is 90 degrees.

As for four poles, the top and the bottom and either side are a pair. X coil, $\bar{X}$ coil and Y coil, $\bar{Y}$ coil correspond respectively. For example, Y coil and $\bar{Y}$ coil are put to the upper and lower pole. Y coil and $\bar{Y}$ coil are rolled up for the direction of the pole to become opposite when applying an electric current to the Y coil and applying an electric current to the $\bar{Y}$ coil. It is similar about X and $\bar{X}$, too.

The turn of the motor is controlled by the electric current which pours into X, $\bar{X}$, Y and $\bar{Y}$. The rotor rotational speed and the direction of the turn can be controlled by this control.

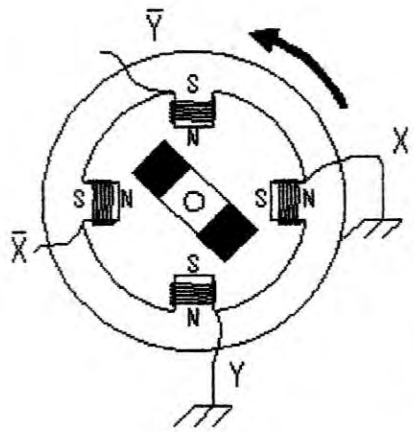


X	$\bar{X}$	Y	$\bar{Y}$
0	1	0	1
1	0	0	1
1	0	1	0
0	1	1	0

X	$\bar{X}$	Y	$\bar{Y}$	Step angle
0	1	0	1	0°
1	0	0	1	90°
1	0	1	0	180°
0	1	1	0	270°

"0" means grounding.

Figure 2.2: Clockwise control



X	$\bar{X}$	Y	$\bar{Y}$
0	1	0	1
0	1	1	0
1	0	1	0
1	0	0	1

X	$\bar{X}$	Y	$\bar{Y}$	Step angle
0	1	0	1	0°
0	1	1	0	-90°
1	0	1	0	-180°
1	0	0	1	-270°

"0" means grounding.

Figure 2.3: Counter clockwise controls

The motor which was used this time is 48 steps and the step angle is 7.5 degrees. The way of controlling is the same as Figure 2.2 and Figure 2.3. It operates when controlling the electric current of X coil, $\overline{X}$ coil, Y coil and $\overline{Y}$ coil. The case of the clockwise control is shown below. The combination of X, $\overline{X}$, Y and $\overline{Y}$ repeats four patterns.

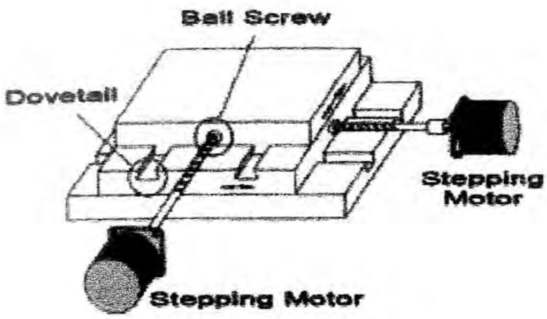
X	$\overline{X}$	Y	$\overline{Y}$	Step angle	X	$\overline{X}$	Y	$\overline{Y}$	Step angle
0	1	0	1	0.0°	0	1	0	1	180.0°
1	0	0	1	7.5°	1	0	0	1	187.5°
1	0	1	0	15.0°	1	0	1	0	195.0°
0	1	1	0	22.5°	0	1	1	0	202.5°
0	1	0	1	30.0°	0	1	0	1	210.0°
1	0	0	1	37.5°	1	0	0	1	217.5°
1	0	1	0	45.0°	1	0	1	0	225.0°
0	1	1	0	52.5°	0	1	1	0	232.5°
0	1	0	1	60.0°	0	1	0	1	240.0°
1	0	0	1	67.5°	1	0	0	1	247.5°
1	0	1	0	75.0°	1	0	1	0	255.0°
0	1	1	0	82.5°	0	1	1	0	262.5°
0	1	0	1	90.0°	0	1	0	1	270.0°
1	0	0	1	97.5°	1	0	0	1	277.5°
1	0	1	0	105.0°	1	0	1	0	285.0°
0	1	1	0	112.5°	0	1	1	0	292.5°
0	1	0	1	120.0°	0	1	0	1	300.0°
1	0	0	1	127.5°	1	0	0	1	307.5°
1	0	1	0	135.0°	1	0	1	0	315.0°
0	1	1	0	142.5°	0	1	1	0	322.5°
0	1	0	1	150.0°	0	1	0	1	330.0°
1	0	0	1	157.5°	1	0	0	1	337.5°
1	0	1	0	165.0°	1	0	1	0	345.0°
0	1	1	0	172.5°	0	1	1	0	352.5°

Table 2.4: Case of the clockwise control

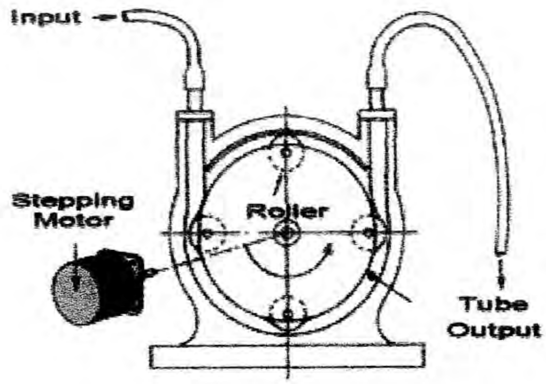
2.1.3 Application

Stepper motors can be found almost everywhere. Most of us use them everyday without even realizing it. For instance, steppers power "analog" wristwatches (which are actually digital), disc drives, printers, robots, cash points, machine tools, CD players, profile cutters, plotters and so on. Unlike other electric motors they do not simply rotate smoothly when switched on. Every revolution is divided into a number of steps (typically 200) and the motor must be sent a separate signal for each step. It can only take one step at a time and each step is the same size, thus step motors may be considered a digital device. See the next page for more applications:

X-Y TABLE



CONSTANT FLOW PUMP



PRINTER

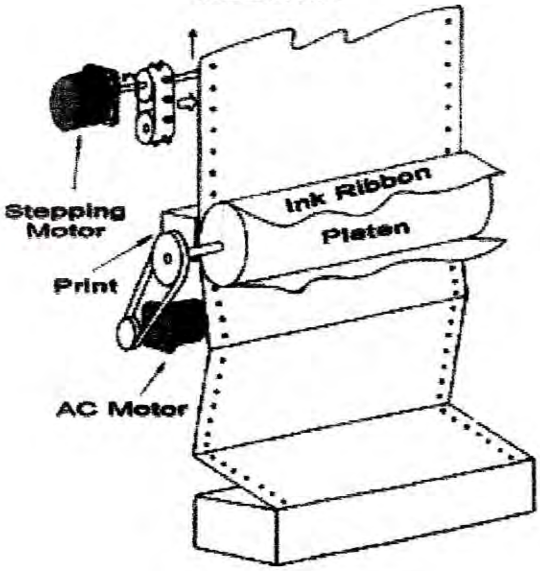


PHOTO TYPESETTING