SOFTWARE BASED STEPPER MOTOR DRIVE USING PERSONAL COMPUTER (PC) AND PARALLEL PORT

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2009

"I hereby declare 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 (Control, Instrumentation and Automation)"

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

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Abstract

This project is about design and implementation of stepper motor driver circuit. Stepper motor driver take input signals for step and direction and output motion on the shaft of the stepper motor. This step and direction signal is come from software running on a PC. Visual Basic software has been use to make a control at pc base. The movement at stepper motor will produce when the driver circuit operates. Parallel port is use to make a connection between driver circuit and computer. To produce a movement at the stepper motor, this project can give a choice to select a method to use at driver circuit. Methods that use are Step- wave, Full-wave, and Half-wave. The method will be select with switching circuit.

This paper reports on the design of a device to rotate a mirror assembly through various angles. A small stepper motor rotates the mirror. The objective of this project was to design the necessary circuitry and software to drive the small stepper motor via a laptop computer's parallel port interface. There are three key components to the project design: (1) mechanical drive, (2) hardware to software interface, (3) computer software to drive the stepper motor via a laptop computer. The three components were successfully integrated to rotate of the stepper motor through forty-five degree increments.

Abstrak

Projek ini agak reka bentuk dan pelaksanaan litar pemacu motor pelangkah. Pemandu motor pelangkah input kesan isyarat-isyarat untuk langkah dan arah dan pengeluaran usul di lubang motor pelangkah. Langkah ini dan isyarat arah adalah didatangkan perisian berlanjutan sebuah komputer persendirian. Perisian asas visual telah gunakan untuk membuat satu kuasa di komputer persendirian asas. Pergerakan motor pelangkah akan menghasilkan apabila litar pemacu beroperasi. Bandar bersaing ialah menggunakan untuk membuat satu hubungan antara litar pemacu dan komputer. Untuk mengeluarkan sebuah pergerakan di motor pelangkah, projek ini boleh memberi satu pilihan bagi memilih satu kaedah menggunakan di litar pemacu. Kaedah-kaedah yang penggunaan adalah gelombang langkah, gelombang penuh, dan gelombang separuh. Kaedah akan menjadi terpilih dengan litar pensuisan.

Kertas ini melaporkan mengenai reka sebuah alat untuk memutar satu perhimpunan cermin sudut-sudut pelbagai yang terus. Satu motor pelangkah yang kecil berputar cermin. Objektif projek ini ialah untuk mereka lingkungan mustahak dan perisian untuk memandu motor pelangkah kecil melalui sebuah komputer riba antara muka bandar bersaing. Terdapat tiga komponen utama untuk tujuan projek: (1) pemacu mekanik, (2) perkakasan untuk antara muka perisian, (3) perisian komputer untuk memandu motor pelangkah melalui sebuah komputer riba. Tiga buah komponen adalah dengan jayanya bersepadu untuk memutar motor pelangkah melalui empat puluh lima ijazah kenaikan.

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CHAPTER 1

INTRODUCTION

Since human society entered the industrial age in the 18_{th} century, motion control, especially precision motion control, has steadily gathered attention in terms of research, development and its application to produce innovation. Precision 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. Driven by the requirements for much higher product performance, higher reliability, longer life and lower cost, numerous advances have been made recently, especially with the help of digital computers. With the emergence of nano-science at the end of the last century, technology in this field advanced a higher level. Today, high precision motion control has become an essential requirement in advanced manufacturing systems such as machine tools, micromanipulators, surface mounted robots, etc.

Generally, motion control systems can be separated into several parts: the mechanical device being move, the motor (servo or stepper) with or without feedback, motion control I/O, motor driver, intellectual controller unit, and programming/operating interface software. Traditional motion control systems utilize PLC technology to fulfill the control task which typically comprises a number of hardware and software elements;

PC for process visualization, hard PLC with coprocessor cards, I/O via field bus, motion control via parallel cabling, a selection of software operating systems and programming languages.

The resulting project design goals are:

- Speed – The stepper motor must turn at a reasonably fast rate. Due to the speed of the spacecraft, the mirror has to quickly focus the sensors in different directions.
- Torque – The stepper motor's holding torque must be enough to sustain the weight of the motor assembly.
- Direction – The user must be able to rotate the mirror in two directions (mirror rotation occurs in one dimension).

The only mechanical component used was a small stepper motor. The shaft of the stepper motor will be connected to the mount of the mirror for rotation. Using a computer interface, positioning commands were fed to the stepper motor via a printer cable to the driver hardware. The hardware amplified the signals and relayed them to the stepper motor. Below clearly shows the design flow.

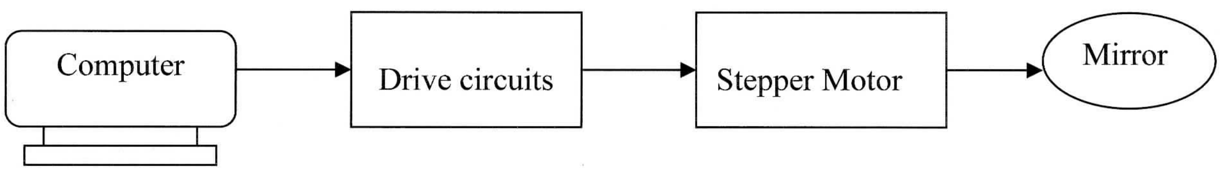

Figure 1.1 Block diagram of Stepper motor-parallel port interface.

The package is designed to enable control of bi-polar stepper motors via the parallel port of a PC. The design is taken largely from the application notes of ST Microelectronics, manufacturer of the chip set on which this product is based. Combining this product with a mechanical system and readily available software to be found on the internet, a way to implementing a CNC machine, engraver, sign-cutter, or any of a number of other useful applications.

This project is focus on stepper motor, reaching ports, and controlling it. The project is allows to control speed, direction, and step size of a stepper motor. If there are interested in robotics, motion control, or just want to learn about this widely used motor in almost every electronic gadget like floppy drives, printer, scanner, robots and every device. Then there should try building this versatile stepper motor control.

This project also provides precious information about the basics of stepper motors, as there is not much literature spread out about it. It will help to go grasp the understanding, and control the master motor. There will also learn how to interact between PC and external devices, (PC interface through parallel port).

1.1 Project Objective

1. To analyze the fundamental and importance of stepper motor drive by using PC parallel port.
2. To make a driver circuit can perform step, full-wave and half-wave method.
3. To extract the relevant information in power signal by using signal processing technique.
4. To design the programming software database using Visual Basic to control the stepper motor movement and condition.

1.2 Scope

1. Design simple circuit to operate the stepper motor to the PC parallel port.
2. Develop Visual Basic programming database
3. Design power supply to suitable for stepper motor source

1.3 Problem Statement

Nowadays, many equipment need to operate in high accuracy movement. Stepper motor is device that can be produced a precise movement. To operate a stepper motor, a complete driver circuit must be used. The stepper motor cannot operate with direct online circuit. It needs a driver that can be control the characteristic of stepper motor. However, it has a various method can use to make a driver circuit.

1.4 Summary

The programming method to control a stepper motor or a servo motor using a parallel port is described. This procedure enables control of a motor using the high resolution performance counter with accuracy exceeding 1 microsecond on most hardware of PC and the algorithm for motion control not have any additional hardware for motion control such as PCI motion control card. The procedure for control of trapezoidal motion is explained in detail here for acceleration, constant speed and deceleration processes written in Visual Basic programming.

The every period of pulses is controlled according to a given acceleration or speed value. This procedure has been applied to control the motion of a turntable for stepper motor. This project also provides precious information about the basics of stepper motors, as there is not much literature spread out about it. It will help to go grasp the understanding, and control the master motor. There will also learn how to interact between PC and external devices, (PC interface through parallel port).

CHAPTER 2

Literature review

2.0 DESIGN PROCEDURE

2.1 Stepper Motor

The first step in the design process was to understand how the stepper motor works. Stepper motors behave differently than standard dc motors. Instead of rotating continuously when power is applied, stepper motors move in small increments or steps. Additionally, a stepper motor is constructed with several coil windings that must be energized in the proper sequence to achieve shaft rotation. For this reason, a simple clock signal will not work. Reversal of the energizing sequence will rotate the shaft in the opposite direction. The stepper motor used in this design is a unipolar type motor. Two center taps characterize unipolar motors. Since each coil is divided in two, one center tap represents two phases [2]. In this case, the motor used is a four-phase motor and thus has two center taps. Figure 2.1 below shows a simplified diagram of a unipolar motor and the energizing sequence.

Index	1a	1b	2a	2b
1	1	0	0	0
2	0	0	1	0
3	0	1	0	0
4	0	0	0	1
5	1	0	0	0
6	0	0	1	0
7	0	1	0	0
8	0	0	0	1

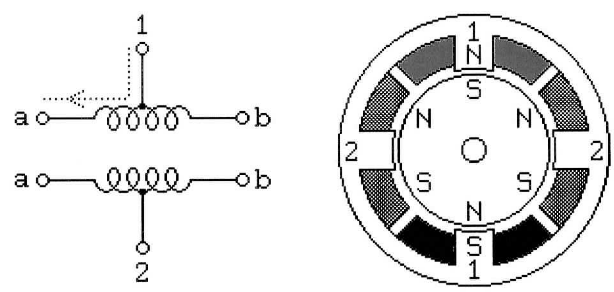

Figure 2.1: Four-phase unipolar stepper motor energizing sequence coil configuration.

If the control signals are not sent in the correct order, the motor will not turn properly. It may simply buzz and not move, or it may actually turn, but in a rough or jerky manner [2]. Figure 2.1 shows the cross section of a motor with an angle resolution of 30 degrees. A permanent magnet with six poles serves as the rotor, three are north polarized and three are south polarized. The specific motor used for this project has an angle resolution of 1.8 degrees per step. Higher resolutions require more poles, 1.8 degrees require 100 poles. Current flows from the center tap of winding 1 to terminal (a) causes the top stator pole to be a north pole and the bottom stator pole to be a south pole. Power is then alternated to winding 2 and causes the rotor to turn. Only one half of each winding is energized at a time.

Stepper motors also have the advantage of producing high torque at low speeds. Direct current motors do not produce high torque at low speeds, without the aid of gearing mechanisms. Stepper motors also have holding torque which allows a stepper motor to hold its position firmly when not turning. This is useful for the intended application where the motor will be starting and stopping, while the force of the mirror's momentum acting against the motor remains present. This eliminates the need for a mechanical brake mechanism. These same principals drive the specific motor used for this project.

Figure 2.2 Stepper motor

2.2 Driver circuit

The motor used for this project requires at least 1 ampere per phase, but the computer's parallel port can only deliver a few milliamperes of current. Since the computer delivers the motor's required 5 volts per phase, a simple application of Ohm's law says that a 5Ω resistor will pull the necessary current. However, most resistors are not capable of pulling current past a few milliamperes. In addition, resistors cannot handle the fast current switching required by the stepping sequence. The inductive loads of the coils tend to make the current reverse direction because of the rapid on and off switching.

Using a Darlington transistor array such as the ULN2003 chip can easily solve these problems. These arrays are composed of cascaded NPN transistors with suppression diodes attached to prevent current reversal. Another advantage of the Darlington transistor is its ability to amplify the computer's output current from a few milliamperes into a 500mA input to the stepper motor. Two transistor elements of each pin are needed in parallel to supply the necessary 1A to the stepper motor. Figure 2.3 below shows the arrangement of NPN transistors and the pin assignments on the chip.

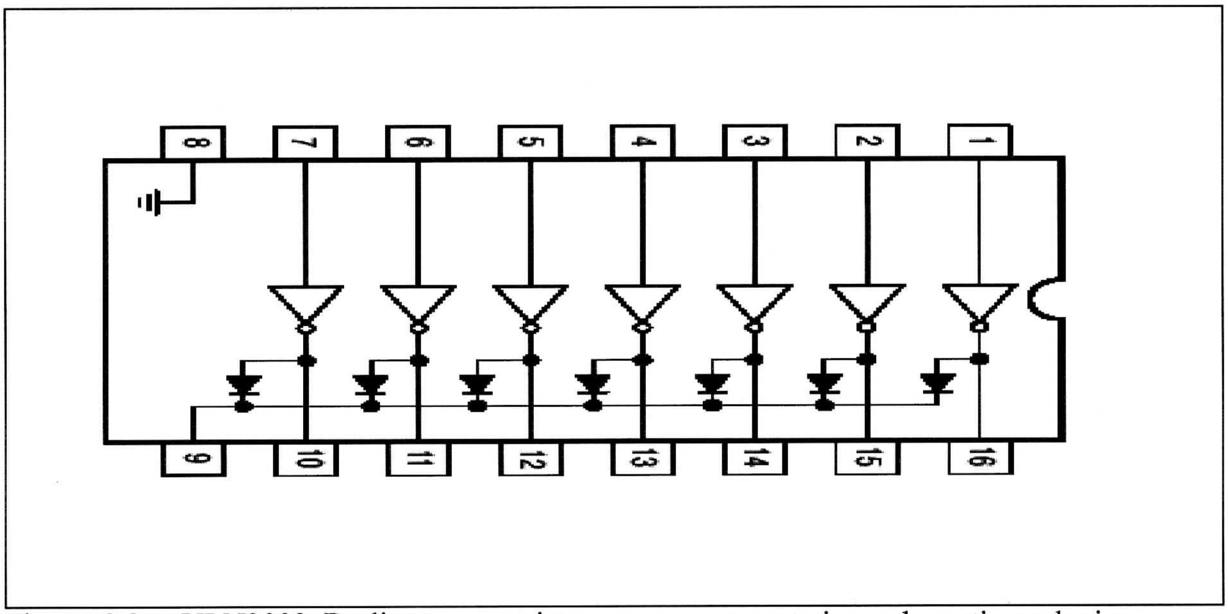

Figure 2.3: ULN2003 Darlington transistor array representative schematic and pin connections

Figure 2.4 on the next page shows the parallel connection of the chips' internal transistors. Pins 1-3 and 4-6 were used as inputs from the computer's parallel port. These pins received the on and off sequence discussed in section 2.1. Pins 14 -16 and 11-13serve as the output of the chips. Current leaving each of the pins was measured to be 344 milliamperes. Only two pins are needed to supply the necessary 500mA, but 3 pins were utilized as a backup feature. You also can be seen from the schematic for each set of outputs is used to feed into one of the stepper motor' coils 1a, 1b, 2a, and 2b.

2.3 Computer Interface

The computer's parallel port was used as the means of communication between the software and the transistor arrays. A 25-pin male, 36-pin female printer cable was used as the bus for information transfer. Figure 2.4 [2] below, shows the pin out arrangement of the parallel port.

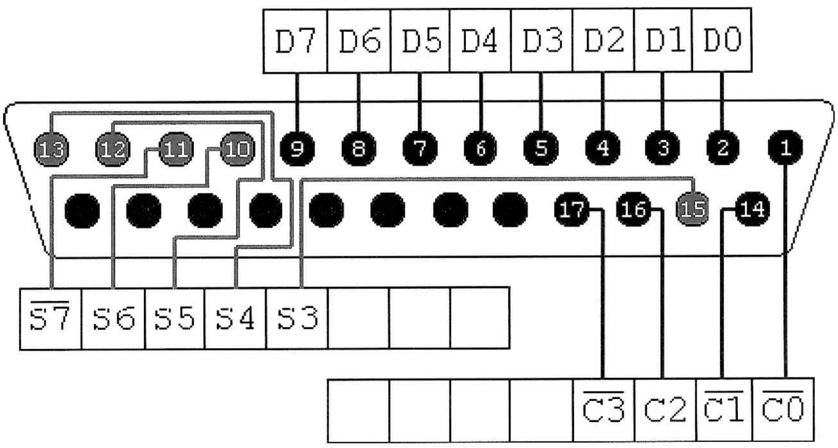

Figure 2.4: Parallel port pin out

The parallel port has three types of output ports [1]; DATA, STATUS, and CONTROL. Figure 3 [2] shows the arrangement of the eight Data pins, D0-D7. Only the DATA pins D0-D3 were used for this application. The port is equipped with all the necessary hardware and is easy to control using a VB program in a Windows environment. No initialization of the port was required. Writing to port 0x378 outputs the necessary data. Two motor control functions were written. All utilized Data pins D0-D3. One function steps the motor clockwise and the other counterclockwise. The VB program can be found at the end of this report in Appendix 1.

The VB program allows the user to select the angle and direction of the motor's motion. The motor turns in 7.5-degree steps until it reaches 45, 90, 135, or 180 degrees. The program also tells the user the new position of the motor each time a motion is completed. This feedback is important in case anything goes wrong with the motor's operation.