STEP MOTOR SPEED CONTROLLER

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I declare that this project report entitled "*Step motor speed controller*" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

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ABSTRACT

Stepper motors are used in many devices and appliances that are part of our everyday life. Sensing variables such as position, velocity or current for the purpose of control is a common problem in many industrial drive applications .Sensing signals that truly represent system variables, such as absolute shaft position, may be a difficult either because of cost or physical limitations. In such cases we must estimate all or some of the missing variables from limited measurements that may be noisy. This project summarizes and shows how to estimate rotor speed using microcontroller. The microcontroller which was used for this purpose is PIC16F84A. Programmable Interface Controller (PIC) 16F84A is use for control the rotation and speed of stepper motor by using the coding that program in software. XCoil, $\overline{X}$coil, Ycoil and $\overline{Y}$coil are controlled by the software. A program in MPLAB IDE is developed to provide a coding to make a HEX file and transfer using PICkit 2 into PIC16F84A.

ABSTRAK

Stepper motor digunakan di banyak peranti dan peralatan yang merupakan sebahagian dari kehidupan seharian kita. Merasakan pembolehubah seperti kedudukan, kelajuan atau saat ini untuk tujuan kawalan adalah masalah umum di banyak aplikasi industri drive sensing isyarat yang benar-benar mewakili pembolehubah sistem, seperti kedudukan aci mutlak, mungkin. Menjadi sukar baik kerana keterbatasan kos atau fizikal. Dalam kes tersebut kita harus menganggarkan semua atau beberapa pembolehubah yang hilang dari pengukuran terhad yang mungkin bising. Projek ini meringkaskan dan menunjukkan bagaimana menganggarkan kelajuan rotor menggunakan mikrokontroler. Mikrokontroler yang digunakan untuk tujuan ini adalah PIC16F84A. Programmable Interface Controller (PIC) 16F84A yang digunakan untuk mengawal putaran dan kelajuan motor stepper dengan menggunakan program pengekodan yang dalam perisian. Coil, koil, kumparan dan kumparan dikendalikan oleh perisian. Sebuah program di MPLAB IDE dibangunkan untuk memberikan pengekodan untuk membuat fail HEX dan pemindahan menggunakan Pickit 2 ke PIC16F84A.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Stepper motor filled a unique niche in the motor control world. These motors are mainly used in measurement and control applications. Sample applications include ink jet printers, CNC machines and volumetric pumps. Several features common to all stepper motors make them ideally suitable for these types of applications. Stepper motors are brushless. The commutator and brushes of conventional motor are some of the most failure prone components and they create electrical arcs that are undesirable or dangerous in some environments. Stepper motor also will not turn at a speed regardless of a load as long as the load does not exceed the torque rating of the motor. Open loop position of stepper motors move in quantified increments of steps. Holding torque characteristic is able to hold the shaft stationary [20]. Stepper Motors come in a variety of sizes, and strengths, from tiny floppy disk motors, to huge machinery steppers. There are two basic types of stepper motors, bipolar and unipolar. The motor which is used in my project is a unipolar stepper motor.

Unipolar Stepper motor has 2 coils, simple lengths of wound wire. The coils are identical and are not electrically connected. Each coil has a center tap - a wire coming out from the coil that is midway in length between its two terminals. If the terminals of a coil are connected, the shaft becomes harder to turn. Because of the long length of the wound wire, it has a significant resistance (and inductance). The resistance from a terminal to the center tap is half the resistance from the two terminals of a coil. Coil resistance of half a coil is usually stamped on the motor. Figure 1.1 shows the cross section of a stepper unipolar motor. Motor winding number 1 is distributed between the top and bottom of stator poles, while motor winding 2 of stepper motor is distributed between left and right of the stator poles. The rotor is permanent magnet with six poles, three north and three south.

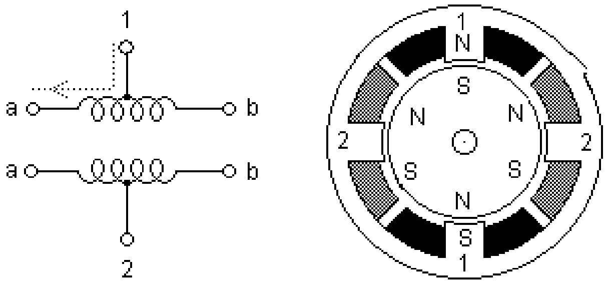

Figure 1.1: Cross section of unipolar stepper motor

The motor is a 2 phase and has 48 poles. In general, for a two-phase stepper, it can be shown that one step results in a rotation given by the equation: 1 step = 360° / P This equation says that a 48-pole motor will rotate 360° / P = 7.5 ° per step.

1.2 Problem Statement

Nowadays stepper motors are ideally suited for measurement and control applications in industry. The stepper motors have their specific problems:

i. Dynamic instability and less efficiency.

ii. Use expensive controller.

The efficiency element is important in order to save cost. The efficiency of speed controller is depending on method control system. The speed controller usually control in analog system.

An analog signal has a continuously varying vale, with infinite resolution in both time and magnitude. For example, a 5 V is input voltage and its output voltage is not precisely to 5 V.

1.3 Objectives

Basically, this project is listing two main objectives. The objectives are a guideline and goal in order to complete this project. This project is conducted to achieve the following:

i. To model and simulate circuit using Proteus.
ii. To develop of stepper motor speed controller using Programmable Interface Controller (PIC16F876A).
iii. To improve the efficiency of stepper motor.

1.4 Scope of Study

In this project, the stepper motor is based on an opened-loop system where the motor operates according to the programming and does not have any feedback from the output to the input. The main goal is to prove the operation and efficiency of the stepper motor which operates according to mathematics calculation.

The scope of this project is:

i. To control stepper motor using PIC16F876A.
ii. To compare the efficiency of classical design.

The software developed is merely to simulate the stepper motor operation. It does not prioritize on design or algorithm of the software. It is not a new program and does not concern about the creativity or feasibility of the algorithm other than to simulate the stepper motor operation.

1.5 Thesis Outline

This thesis contains five (5) chapters. Chapter I give out the introduction to the project which tells about the project background, scopes and also an overview of the whole chapters in this thesis.

Chapter II is a literature review that elaborates and explains all the research information that is needed on order to complete the project. The source of the content involves journals, papers websites, article, magazine and books.

Chapter III discuss about the system design method that is used to complete the project. This chapter also includes the overview of the whole system which is communication module, controller module and detection module.

Chapter IV discusses all the result obtained after all modules have been combining. The result of the integration between all modules will be showed in this chapter.

Chapter V is a conclusion of the whole project system. This chapter also suggests the future recommendation to make this project more reliable and quality for commercialization.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This part will explain the research information that is related to completing this project. All the research sources are from books, journals, some articles and websites.

2.2 Linear speed control of stepper motor

This application note describes how to implement an exact linear speed controller for stepper motors. The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. Many advantages are achieved using this kind of motors, such as higher simplicity, since no brushes or contacts are present, low cost, high reliability, high torque at low speeds, and high accuracy of motion. Many systems with stepper motors need to control the acceleration/ deceleration when changing the speed. This application note presents a driver with a demo application, capable of controlling acceleration as well as position and speed [2].

2.2.1 Bipolar vs. Unipolar stepper motors

The two common types of stepper motors are the bipolar motor and the unipolar motor. The bipolar and unipolar motors are similar, except that the unipolar has a center tap on each winding as shown in Figure 2.1 and Figure 2.2.

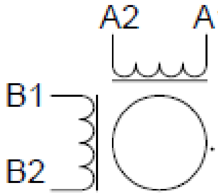

Figure 2.1: Bipolar stepper motor

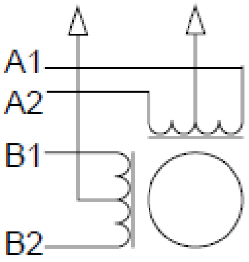

Figure 2.2: Unipolar stepper motor

The bipolar motor needs current to be driven in both directions through the windings, and a full bridge driver is needed as shown in Figure 2.3. The center tap on the unipolar motor allows a simpler driving circuit, also shown in Figure 2.3, limiting the current flow to one direction. The main drawback with the unipolar motor is the limited capability to energize all windings at any time, resulting in a lower torque compared to the bipolar motor. The unipolar stepper motor can be used as a bipolar motor by disconnecting the center tap [4], [5].

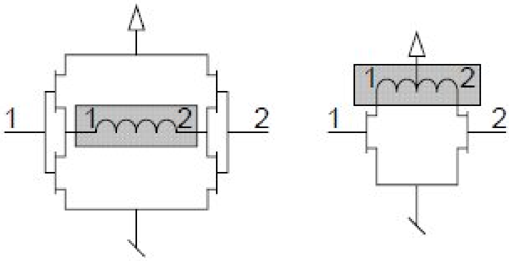

Figure 2.3: Bipolar and Unipolar drivers with MOS transistors

2.2.2 Speed controller

The speed controller calculates and generates the speed profile. The block diagram for the speed controller is shown in Figure 2.4. To run the stepper motor, the speed controller is set up by calling the function Move ().

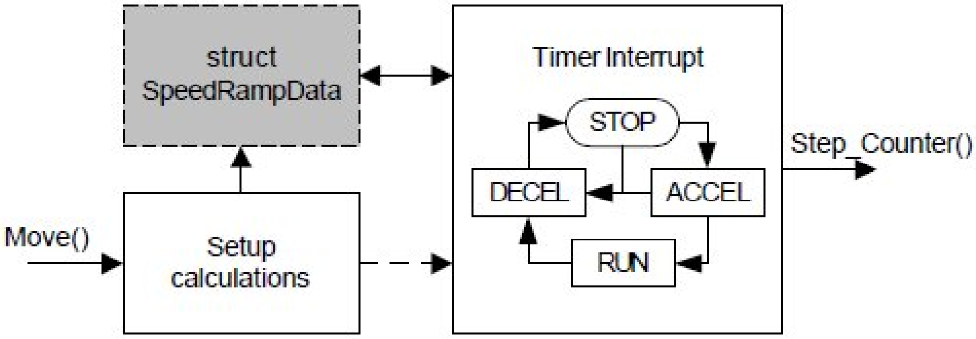

Figure 2.4: Block diagram of speed controller

The function Move () first calculates all the parameters needed and stores them in the speed ramp data struct, and then it enables the timer interrupt. The timer generates interrupts according to the desired speed ramp, and calls the function Step Counter () on each interrupt to move the stepper motor [4], [5].

2.3 A stepper motor controller

Open loop control of stepper motors suffers from a major disadvantage that the rotation of the rotor becomes oscillatory and unstable in certain speed ranges. This paper presents the microstepping technique which overcomes the problem of instability and at the same time provides for high accuracy of microsteping applications. This technique improves electronically the resolution of stepper motors and suppresses oscillations due to effects of mechnical resonance. Another key feature is the capability of the controller to control multiple number of stepper motors for simultaneous operations (independent and/or synchronized). This has greatly enhanced its usefullness in modern control applications. The application of the stepper motor controller for an X-Y table is one of the examples. The table is capable of very accurate point-to-point traversing. Basically, the controller is used in conjunction with the standard IC stepper motor drivers such as SGS L297 and L7180. These chips are capable of driving the stepper motor in full and half step operations. This paper describes the techniques used in achieving the microstepping capability of the controller where a full step is broken into smaller intermediate microsteps [18].

2.3.1 Driver circuit for stepper motor

One of the most important considerations in the stepper motor applications is the design of appropriate drive circuits. The dynamic performance of a stepper motor is heavily dependent on the drive circuits. Driving a stepper motor requires the switching of current from one stator winding to another. This switching function is provided by the driver circuit which arranges, distributes and amplifies pulse trains from the signal circuit. The windings of the stepper motor are excited at specified sequence.

The availability of integrated circuit drivers has made the building of circuits using discrete components unneccesary for small stepper motors of rating less than 3 amperes. For example, the SGS L7180 and L7182 for unipolar drives and L293 and L298 for bipolar drives can be readily used in compact controllers.

2.3.2 Stepping mode

The position resolution that can be obtained from a stepper motor is basically limited by its mechanical design. From the earliest stepper motor with four steps per revolution to present day stepper motors with 400 steps per revolution, there has been a tremendous improvement in the resolution. However, for high precision positioning applications, even this position resolution may be inadequate. For example, certain equipment now being used to produce electronic integrated circuits may require mechanical motion precisely controlled in steps of only about 0.1 micrometer [8]. Since the minimum step that can be produced by a stepper motor is determined by its mechanical design (mainly the number of poles or teeth in the stator and the rotor), a limit is soon reached where other means must be employed to subdivide the step angle in order to improve the resolution. This paper describes one approach to achieve the improved resolution electronically. Essential to the operation of the stepper motor is the stator current timing sequence. By appropriately controlling this stator current timing sequence, the stepper motor would be driven into the required position resolution. The most important benefit of microsteppingis improved position resolution. Other positive feature is the reduction in ripple torque, especially at lower motor speeds. By microstepping, with its higher frequency pulse rates and smaller step angles, the overshoot is reduced and resonance is not triggered.

2.4 The L297 stepper motor controller

The L297 Stepper Motor Controller is primarily intended for use with an L298N or L293E bridge driver in stepper motor driving applications. It receives control signals from the system's controller, usually a microcomputer chip, and provides all the necessary drive signals for the power stage. Additionally, it includes two PWM chopper circuits to regulate the current in the motor windings. With a suitable power actuator the L297 drives two phase bipolar permanent magnet motors, four phase unipolar permanent magnet motors and four phase variable reluctance motors. Moreover, it handles normal, wave drive and half step drive modes. Two versions of the device are available: the regular L297 and a special version called L297A. The L297A incorporates a step pulse double and is designed specifically for floppy-disk head positioning applications. The L297 + driver combination has many advantages: very few components are required (so assembly costs are low, reliability high and little space required), software development is simplified and the burden on the micro is reduced. Further, the choice of a two-chip approach gives a high degree offlexibilitytheL298Ncanbeusedonitsownfor DC motors and the L297 can be used with any power stage, including discrete power devices (it provides 20mA drive for this purpose).

Since the L297 is normally used with an L298N or L293E bridge driver a brief review of these devices will make the rest of this note easier to follow. The L298N and L293E contain two bridge driver stages, each controlled by two TTL-level logic inputs and a TTL-level enable input. In addition, the emitter connections of the lower transistors are brought out to external terminals to allow the connection of current sensing resistors (figure 2.5). For the L298N STMicroelectronics' innovative ion-implanted high voltage/high current technology is used, allowing it to handle effective powers up to 160W (46V supply, 2A per bridge) [13], [14]. A separate 5V logic supply input is provided to reduce dissipation and to allow direct connection to the L297 or other control logic. In this note the pins of the L298N are labelled with the pin names of the corresponding L297 terminals to avoid unnecessary confusion. The L298N is supplied in a 15-lead Multiwatt plastic power package. Its smaller brother, the functionally identical L293E, is packaged in.

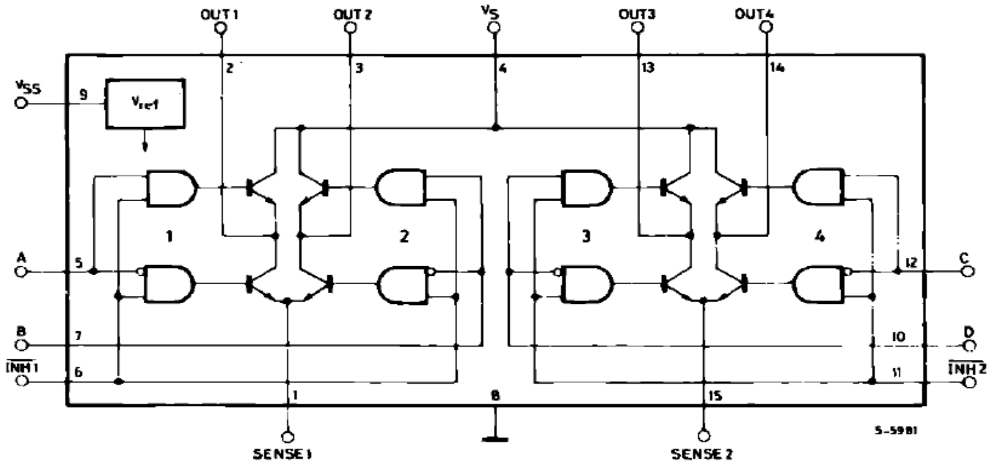

Figure 2.5: The L298N contains two bridge drivers each controlled by two logic inputs and an enable input.

2.5 Stepper motor control with an MC68HC11E9 microcontroller

This note provides basic implementation details and procedural information to design and assemble a stepper motor system. The controller discussed here is the MC68HC11E9, an 8-bit free scale microcontroller (MCU). There are many embedded control applications supported by the M68HC11 Family. The note consists of a general description and gives highlights of implementing a basic stepper motor system application. A step-by-step hardware assembly section is included to promote ease of construction should one desire to build a similar system.

To simplify the application, the software was generated on the Free scale M68HC11EVM evaluation module (EVM). The program created with the EVM is shown in 6 listing the program runs in addresses $C000 through $C1CC. It is meant to be used as a guide and can be modified to support a variety of stepper motor control applications. Some modules will require no changes for use. For convenience, a copy of the code is available through Freeware Data Services.

The EVM comes with an on-board monitor called EVMbug11 that supports software development. This evaluation system provides easy I/O interfacing to external hardware and offers the user an inexpensive programming solution for devices with OTP, EPROM and EEPROM non-volatile memory

Evaluation of the A0, A1, A8, E0, E1, E9 or 811E2 versions of M68HC11 microcontroller devices is supported when using the EVM. The microcontroller that resides on the EVM for this application is the MC68HC811E1 version.

2.5.1 General system information

Figure 2.6 shows basic system operation. R1 provides an analog input to the MCU which is converted to a digital value and used to determine the speed at which the motor turns. In this example, the resistance is being varied manually for the A/D input to the MCU. A feedback scheme from the motor back to the A/D input could be implemented to facilitate a closed loop system.

To support motor turn direction, one I/O port pin is used to determine clockwise or counter-clockwise rotation. The voltage applied to the pin is sampled each time the program cycles through the software routines. A manual switch controls the state of the I/O pin. Green and yellow LEDs illuminate to indicate the turn direction.

A seven-segment display shows the delay between steps when the stepper motor is driven, and indicates motor speed. A parallel port is used to send the appropriate