DEVELOPMENT OF AN EMBEDDED CONTROLLER FOR STEPPER MOTORS APPLICATION

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MAY 2008

"I hereby declared that I have read through this report and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)"

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This Report Is Submitted In Partial Fulfilment of Requirement for the Degree of Bachelor in Electrical Engineering (Power Electronic and Drive)

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MAY 2008

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

Signature	: …………………………………………………
Name	: …………………………………………………
Date	: …………………………………………………

To beloved father and mother

ACKNOWLEDGEMENT

In submitting this report, I would like to thanks my supervisor Projek Sarjana Muda (PSM) - Professor Madya Dr. Zulkifilie bin Ibrahim, for his guidance and participation in conducting my project. His knowledge and insights were invaluable in identifying the ways to solve my problems regarding to my project.

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ABSTRACT

The project is titled as "**Development of an embedded controller for stepper motors application**". In this project, the embedded controller developed is based on Rabbit microprocessor and its core module model RCM 2000. This project is to design and develop variable speed controlled stepper motor drive using rabbit microprocessor. The control method implemented in this project is variable speed control method. Instead of using assembly language to compile the variable speed; this controller will use Dynamic C programming language to develop the algorithm.

The goal of the project is to design and develop a laboratory scale functioning prototype in order to demonstrate the interfacing between the variable speed algorithm in Rabbit microprocessor and the stepper motor speed drive. The Rabbit microprocessor based variable speed controller is able to generate pulse wave signal. The desired pulse wave signal generated is an input signal for stepper motor speed drive in order to control the speed of stepper motor.

The major hardware implementation in this project is Rabbit microprocessor. Rabbit microprocessor is chosen due to its specification features of high speed, easy-design hardware system and low power consumption. Besides, variable speed driver also need to be developed to operate with two units of stepper motors or more.

ABSTRAK

Projek ini bertajuk "Pembangunan pengawal padat dan komplek untuk aplikasi motor stepper dengan menggunakan mikropemproses Rabbit." Dalam projek ini, satu pengawal padat yang dibangunkan adalah berteraskan mikropemproses Rabbit dan modul terasnya RCM 2000. Pengaturcara yang digunakan dalam projek ini adalah pengawalan perbezaan kelajuan. Satu algoritma kawalan kelajuan perlu dibangunkan dan dikompil ke dalam mikropemproses Rabbit agar dapat memberikan isyarat kawalan yang tepat kepada pemacu kelajuan motor stepper. Daripada menggunakan bahasa himpunan, pengawal yang akan direkacipta ini menggunakan bahasa pengaturcaraan Dynamic-C yang dikhaskan untuk mikropemproses Rabbit.

Matlamat projek ini adalah untuk merekacipta dan membangunkan satu prototaip berskala makmal. Prototaip ini diharapkan dapat mendemonstrasikan pengantaraan yang baik antara algoritma kawalan kelajuan yang dibangunkan dalam mikropemproses Rabbit, dengan pemacu kelajuan motor stepper. Pengawal laju asas mikropemproses Rabbit mampu menjanakan isyarat Pulse Wave. Isyarat Pulse Wave yang terjana akan dijadikan isyarat masukan untuk pemacu dan seterusnya pemacu kelajuan dapat mengawal kelajuan motor stepper.

Mikropemproses Rabbit dipilih sebagai perkakasan yang utama adalah disebabkan kelajuan yang tinggi, perekaan perkakasan yang mudah serta peresapan kuasa yang sedikit yang ditampilkan olehnya. Selain itu, satu pemaju perlu dibangunkan untuk beroperasi bersama dua atau lebih motor stepper supaya mendapat kelajuan yang berbeza untuk menjalankan tugas yang lain dalam pelbagai bidang.

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LIST OF ABBREVIATIONS

AC	- Alternating Current
RCM	- Rabbit Core Module
PC	- Personal Computer
I/O	- Input/ Output
RAM	- Random Access Memory
DC	- Direct Current

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CHAPTER 1

INTRODUCTION

1.1 Objectives

- To generated desire *pulse wave* signal as an input signal for stepper motor speed drive in order to control the speed of stepper motors by using *Rabbit Microprocessor*.
- To develop a user interface (push buttons, on-off switches) programming to interface with multi-stepper motors.

1.2 Scope

- Develop a speed control algorithm to drive the stepper motors.
- Develop the desire pulse waves by using Dynamic C programming.
- Develop an IC type stepper motor driver.
- Develop a programming to interface with multi-stepper motors.
- Develop a user interface (push buttons, on-off switches) variable speed stepper motors.

1.3 Problem Statement

Nowadays, the conventional controller of stepper motors speed mostly based on Digital Signal Processor (DSP), Programmable Logic Controller (PLC) or PC-based controller. Furthermore, these controllers might be costly and difficult to be re-programmed. Hereby, on the terms of cost effective and easy to program, a controller with minimize number of components need to de developed by using 8 bits Rabbit microprocessor.

The main objective is to design and develop variable speed stepper motor by using rabbit microprocessor. The desired pulse waves are creating to generate the variable speed stepper motor by using Rabbit Core Module (RCM 2000) prototyping board. Examples for the application of stepper motors are X-Y plotters, electric typewriters, and control of disk drives, robots, and numerical control of machine tools.

The variable speed drive will be designed to interface with the stepper motor. Hence, by using Dynamic C language known as high level programming language will be develop to compile into the memory system of Rabbit Microprocessor. Then, the rabbit microprocessor of RCM 2000 will be integrating with the stepper motors in order to run in real time and debug for variable speed.

CHAPTER 2

LITERATURE REVIEW

2.1 Embedded Systems

Basically an embedded system consists of:

- Microcontroller, digital signal processor (DSP)
- Random access memory (RAM), disk on chip
- Flash memory
- Power consumption 3V-12V
- Microprocessor based 32 bits- 64 bits
- Peripheral input and output (I/O)
- Operating system (OS)
    i. Disk operating system (DOS)
    ii. Window CE
    iii. Linux

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale. [1]

Physically, an embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems - such as the operating systems and microprocessors which power them - but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected.

Figure 2.1: Embedded circuit

2.2 Stepper Motors

Stepper motor is a permanent magnet or variable reluctance dc motor that has the following performance characteristics:

1. Rotation in both directions,
2. Precision angular incremental changes,
3. Repetition of accurate motion or velocity profiles,
4. A holding torque at zero speed, and
5. Capability for digital control.

Commonly the stepper motors can be divided in two types:

- **Unipolar stepper motors**
- **Bipolar stepper motors**

A stepper motor is an electric machine that rotates in discrete angular increments or steps. Stepper motors are operated by applying current pulses of a specific frequency to the inputs of the motor. Each pulse applied to the motor causes its shaft to move a certain angle of rotation, called a stepping angle. [2]

The stepper motor also possesses drawbacks such as the possibility of losing synchronism, harmonic resonance, and small oscillations at the end of each step. With the above parameters in mind, the stepper motor is used in applications such as printers, plotters, X-Y tables, facsimile machines, barcode scanners, image scanners, copiers, medical apparatus, and other devices. The stepper motor has salient poles on both the stator and the rotor, and normally only the stator poles hold the poly-phase windings called the control windings. Usually stepper motors are classified as

- Active rotor (permanent magnet rotor)
- Reactive rotor (reluctance type)
- Hybrid motors (combining the operating principles of the permanent magnet (PM) and reluctance stepper motor)

While each of these types of stepper motors has merit, hybrid stepper motors are becoming more popular in industrial applications. In this chapter, we focus on the principles and implementation of a hybrid stepper motor control system using the LF2407 DSP controller.

A stepper motor can move in accurate angular increments know as steps in response to the application of digital pulses to an electric drive circuit from a digital controller. The number and rate of the pulses control the position and speed of the motor shaft. Generally, stepper motors are manufactured with steps per revolution of 12, 24, 72, 144, 180, and 200, resulting in shaft increments of 30, 15, 5, 2.5, 2, and 1.8 degrees per step.

Stepper motors are either bipolar, requiring two power sources or a switchable polarity power source, or unipolar, requiring only one power source. They are powered by dc current sources and require digital circuitry to produce the coil energizing sequences for rotation of the motor. Feedback is not always required for control, but the use of an encoder or other position sensor can ensure accuracy when it is essential. The advantage of operating without feedback is that a closed loop control system is not required. Generally, stepper motors produce less than 1 horsepower (746W) and are therefore frequently used in low-power position control applications.

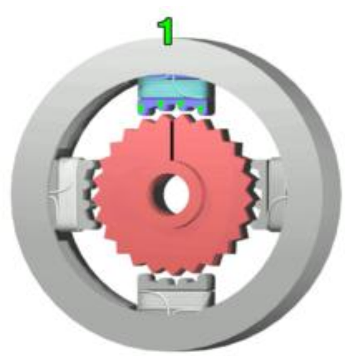

Figure 2.2a: The top electromagnet (1) is charged, attracting the top most four teeth of a sprocket.

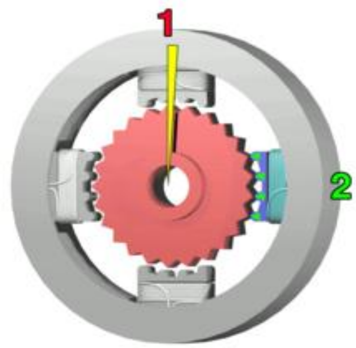

Figure 2.2b: The top electromagnet (1) is turned off, and the right electromagnet (2) is charged, pulling the nearest four teeth to the right. This results in a rotation of 3.6 °.

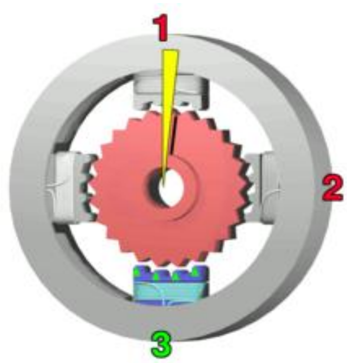

Figure 2.2c: The bottom electromagnet (3) is charged; another 3.6° rotation occurs.