DEVELOPMENT OF PC BASED INTERFACE
CARD FOR DC DRIVE SYSTEM

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APRIL 2009

“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.”

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Name : ……………………………………..

Date : ……………………………………..

DEDICATION

To my beloved mother Shaharom bt Aziz and to my supervisor Pn Intan Azmira bt Wan abdul Razak and to all my friends for all their support throughout my studies. Last but not least to a special person in my life who encourage and motivate me to work harder into achieving my goals.

DEVELOPMENT OF PC BASED INTERFACE CARD FOR DC MOTOR DRIVE SYSTEM

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This Report is submitted in Partial of Requirements for the Degree of Bachelor in Electrical Engineering (Mechatronic)

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April 2009

“I hereby declared 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 (Mechatronic).”

Signature : ……………………………………..
Supervisor Name : ……………………………………..
Date : ……………………………………..

ABSTRACT

Tujuan pengawalan motor arus terus yang berdigital adalah untuk menggunakan satu isyarat digital yang mewakili bekalan voltan purata kepada motor arus terus tersebut. Konsep operasi dan cara kawalan laju motor arus terus perlu dipelajari dan dikaji. Dengan itu, projek ini perlu dalam merekabentuk dan membangunkan sistem kad antaramuka kelajuan arus terus motor berasaskan komputer. Projek ini dibahagikan kepada dua bahagian iaitu bahagian merekabentuk litar untuk kawalan arus terus motor dan bahagian untuk antaramuka di antara komputer dengan mikropemproses secara bersiri. Di dalam bahagian yang pertama, PIC 16F873 mikropemproses dan A3953SB Full-Brige Litar Bersepadu digunakan. PIC 16F873 mikropemproses diperlukan untuk menghasilkan isyarat atau gelombang Pulse Width Modulation (PWM). Gelombang PWM adalah sangat penting dalam menggunakan A3953SB Full-Brige Litar Bersepadu supaya arus terus motor dapat dikawal. Gelombang PWM dikira dengan menentukan had frekuensi dan had kitaran kerja (duty cycle). Julat had frekuensi yang dihasilkan ialah dan julat had kitaran kerja ialah 10%29100*kHzfkHz*≤≤90%*D*≤≤. Seterusnya, kod yang dibangunkan menggunakan bahasa Programmable BASIC dihubungkaitkan dengan PIC 16F873 mikropemproses. A3953SB Full-Bridge Litar Bersepadu mempunyai 4 pin utama iaitu ENABLE, MODE, PHASE, dan BRAKE. Keempat-empat pin ini perlu dihubungkan kepada PIC 16F873 mikropemproses supaya laju arus terus motor tersebut dapat dikawal. Di dalam bahagian pengantaramuka komputer, sistem ini dihubungkaitkan dengan menggunakan kabel sesiri (DB9). Perisian platform, MPLAB digunakan untuk berkomunikasi dengan system kad antaramuka. Perisian ini bertindak seperti HyperTerminal untuk data komunikasi. Kesimpulannya, keputusan yang dijangkakan untuk projek ini ialah laju arus motor itu boleh dikawal dan berkomunikasi secara bersiri dengan komputer untuk tujuan kawalan berasaskan komputer.

ABSTRAK

The purpose of a digital direct current (DC) motor control is to use a digital signal representing the demanded average voltage supply to DC motor. Operating and driving speed concept of a DC motor need to be study. Therefore, this project has to take a part to design and develop a computer-based DC motor speed drive interface card system. The project has divided to two parts which are DC motor drive circuit design and Personal Computer (PC) to microprocessor serial communication interface. On the first part, PIC 16F873 microcontroller and A3953SB Integrated Circuit (IC) Full-Bridge driver motor is used. PIC 16F873 microcontroller is used to generate Pulse Width Modulation (PWM) signal. The PWM signal is important in order to use the A3953SB Full-Bridge driver for driving the DC motor. PWM signal is calculated by determine the frequency limit and duty cycle limit. The frequency limit is about $29100 kHz f kHz \leq \leq$ and duty cycle limit is about10%. Then, the PIC 16F873 microcontroller is interfaced using coding which is developed using Programmable BASIC language. The A3953SB Full-Bridge driver has 4 main pins which are ENABLE, MODE, PHASE, and BRAKE pins. These 4 pins need to be connected to PIC 16F873 microcontroller in order to drive and control the speed of the DC motor. On the PC interfacing part, the system is interfaced to the PC using serial cable (DB9). The platform software, MPLAB is used to communicate with the interface card system. This software acts like HyperTerminal for data communication. As a conclusion, the expected result of this project is the speed of a DC motor can be control and communicate serially to the PC for computer-based control purpose. $90\% D \leq \leq$

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CHAPTER 1

INTRODUCTION

1.1 Background

This chapter explains the operation of a direct current (DC) motor and its implementation to the industry. The development of DC motor speed control also discusses and briefly explains in this chapter. This chapter also explains the overview of project objectives, project scopes and thesis outline.

1.2 DC Motor

DC motors are commonly and widely used in many industrial applications as the primary power source. Basically, in any DC motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field. A small DC motor generates torque by creating an interaction between a fixed and rotating magnet field. Generally, the rotational speed of a DC motor is proportional to the voltage applied to it, and the torque is proportional to the current. Speed control can be achieved by variable battery tapping, variable supply voltage, resistors or electronic controls.

In many industrial and general applications it is desired that the speed of motor is restored and maintained during any disturbances to a set value. By inducing disturbances in this scaled down model and taking feedback from the output using a controlling scheme or algorithm. The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. The controller may or may not actually measure the speed of the motor. The speed of a DC motor is directly proportional to the supply voltage, so if we reduce the supply voltage from 12 Volts to 6 Volts, the motor will run at half the speed.

The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and the field current will change the rotor speed. Extremely good speed control from standstill to full speed, and consistent torque for DC motor can be obtained by varying the generator and motor field current.

1.3 Objective

The objective of this project is to develop PC-based interface drive circuit for DC motor. The DC motor drive system has to communicate with the PC in serial connection and user will be able to control the speed of the DC motor.

1.4 Scope

The scopes of this project are to design motor speed drive interface unit circuit using PIC 16F873 microcontroller for 12V DC motor. Besides that, the project is for non-load cases.

1.5 Thesis Outline

Chapter 1 explains the operation of a direct current (DC) motor and its implementation to the industry and the development of DC motor speed control. The overview of project objectives and project scopes also discuss in this chapter.

Chapter 2 focuses on the literature review that related to this project. The DC motor characteristic, Pulse Width Modulation, PIC 16F873 microcontroller, A3953 Full-Bridge driver and RS-232 serial port are discuss in this chapter.

Chapter 3 discusses about the methodologies of computer-based interface card system design for DC motor drive including PIC microcontroller interface, PC-based interface and also PWM calculation. This chapter also explains the software development and also the operation of the Computer-based Interface Card System for DC motor drive.

Chapter 4 explains and discusses all the results obtained and the analysis of the project. All discussions are concentrating on the result and performance of the DC motor output.

Chapter 5 discusses the conclusion of development of the project system. This chapter also discusses the problem and the recommendation for this project and overall system for the future development or modification.

CHAPTER 2

LITERATURE REVIEW

In order to perform this project, literature review have been made from various sources likewise journal, books and other references such as article. In simple term, the reference sources emphasize on few aspects and the important aspect is the how to construct the interface card for the DC motor drive. This chapter will describe about DC motor, PWM duty cycle, PIC16F873, A3953 full bridge driver, RS-232 serial port, and bidirectional dc motor speed control.

2.1 DC Motor Characteristic

Basically, in any DC motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field then placed in an external magnetic field. A small DC motor generates torque by creating an interaction between a fixed and rotating magnet field. Every DC motor has six basic parts which are axle, rotor (armature), stator, commutator, field magnets, and brushes.

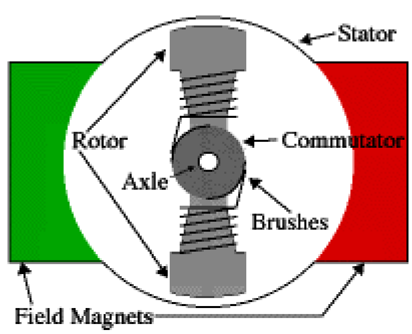

Figure 2.1: A Basic DC Motor.

DC motors are divided into three classes, designated according to the method of connecting the armature and the field windings as shunt-series and compound wound. When current passes through the coil wound around a soft iron core the side of the positive pole is acted upon by an upwards force, while the other side is acted upon by a downward force.

The main purpose of a DC motor speed controller is to take a signal representing the demanded speed, and to drive the motor at that speed. The controller may or may not actually measure the speed of the motor. If it does, it is called a Feedback Speed Controller or Closed Loop Speed Controller, if not it is called an Open Loop Speed Controller. Feedback speed control is better, but the system is more complicated.

2.2 PWM using PIC 16F873 Microcontroller

Pulse Width Modulation (PWM) and the driving motor circuit are respectively related to each other. PWM is generated by using PIC 16F873 microcontroller in order to control the DC motor. In this project, PWM acts as a tool to control speed of a DC motor. The principle is based on using of square wave (duty cycle) for variation value of waveform. This is for generating the motor drive signal. The torque applied to the motor is determined by PWM duty cycle. The speed of the DC motor is depending on duty cycle of PWM signal. PWM is also economical, space saving, and noise immune.

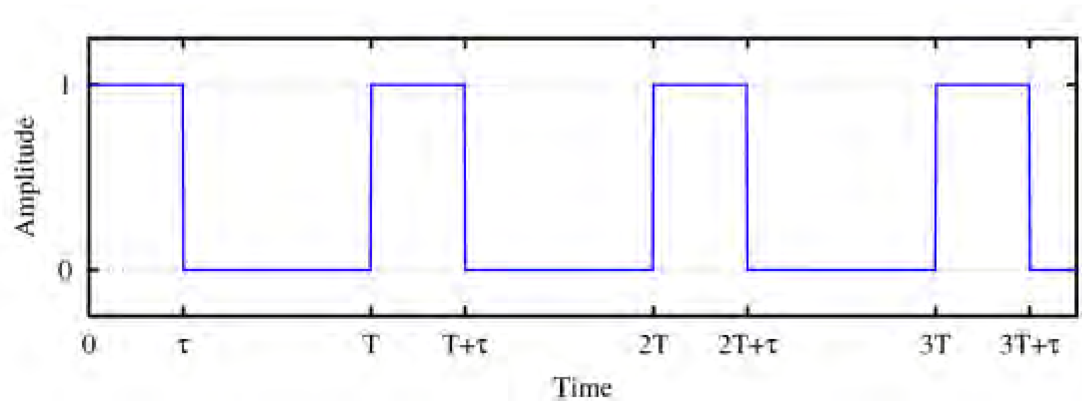

Figure 2.2: Example of PWM Duty Cycle Signals

Pulse Width Modulation control works by switching the power supplied to the motor on and off very rapidly. The DC voltage is converted to a square-wave signal. By adjusting the duty cycle of the signal (modulating the width of the pulse, hence the 'PWM') i.e., the time fraction it is "on", the average power can be varied, and hence the motor speed.

The software MPLAB is used as coding compiler for the microcontroller. PIC 16F873 has 28 pins. The important pins that use to generate Pulse Width Modulation signal is CCP2 pin and named as PWM1 output.

PWM Frequency	1.22 kHz	4.88 kHz	19.53 kHz	78.12kHz	156.3 kHz	208.3 kHz
Timer Prescaler (1, 4, 16)	16	4	1	1	1	1
PR2 Value	0xFFh	0xFFh	0xFFh	0x3Fh	0x1Fh	0x17h
Maximum Resolution (bits)	10	10	10	8	7	5.5

Figure 2.3: PWM Frequency Configuration for PIC 16F87X Series

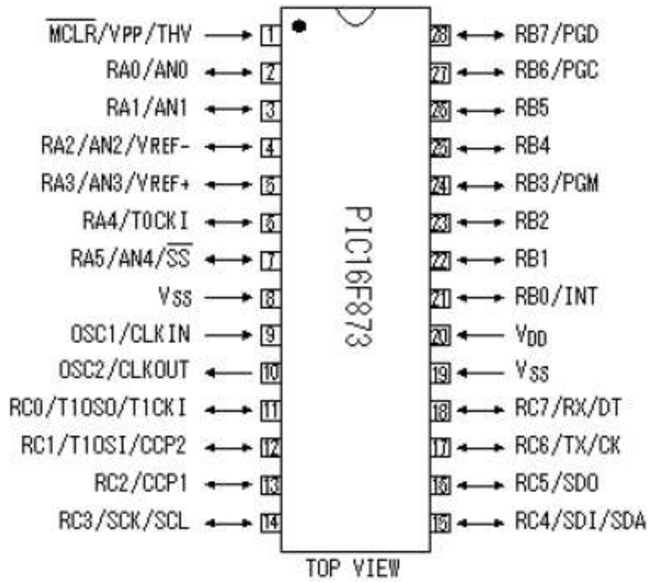

Figure 2.4: PIC 16F873 Pins Configuration

In Pulse Width Modulation mode, the CCP1 pin produces up to a 10-bit resolution PWM output. Since the CCP1 pin is multiplexed with the PORTC data latch, the TRISC<2> bit must be cleared to make the CCP1 pin an output. The Pulse Width Modulation calculation is focus on period and duty cycle. The PWM calculation is shown in Chapter 3.

The PWM period is specified by writing to the PR2 register. The PWM period can be calculated using the following formula:

PWM period = [(PR2) + 1] • 4 • TOSC • (TMR2 prescale value)
PWM frequency is defined as 1 / [PWM period].

When TMR2 is equal to PR2, the following three events occur on the next increment cycle:

i. TMR2 is cleared.

ii. The CCP1 pin is set (exception: if PWM duty cycle = 0%, the CCP1 pin will not be set).

iii. The PWM duty cycle is latched from CCPR1L into CCPR1H.

2.3 A3953SB Full Bridge Integrated in DC Motor Mode

A3953SB Full-Bridge driver is an Integrated Circuit (IC) that is design for bidirectional Pulse Width Modulation (PWM) current control of inductive loads. The driver is capable of continuous output currents to ±1.3 A and operating voltages to 50 V. The fixed off-time pulse duration is set by user by choosing external RC timing network.

A3953SB Full-Bridge driver has 4 main pin for driving the motor. These 4 pins are ENABLE, BRAKE, MODE and PHASE. Each pin has it own function. ENABLE pin must be in active low condition for driving the motor. It is because, with the ENABLE input held low, the PHASE input controls load current polarity by selecting the appropriate source and sink driver pair. If the ENABLE pin is in high condition, all output drivers are disabled. A sleep mode is provided to reduce power consumption. The MODE pin determines whether the PWM current-control circuitry operates in a fast current-decay mode or in slow current-decay mode.

When a logic low is applied to the BRAKE pin, the braking function is enabled. This is because BRAKE pin also active in low condition. This overrides ENABLE and PHASE to turn off both source drivers and turn on both sink drivers. The brake function can be used to dynamically brake brush DC motors.

For PWM purpose, the PHASE and ENABLE pins can be pulse width modulated to regulate load current. If the internal PWM current control is used, the comparators blanking function is active during phase and enable transitions. This eliminates false tripping of the over-current comparator caused by switching transients related to distributed capacitance in the load.

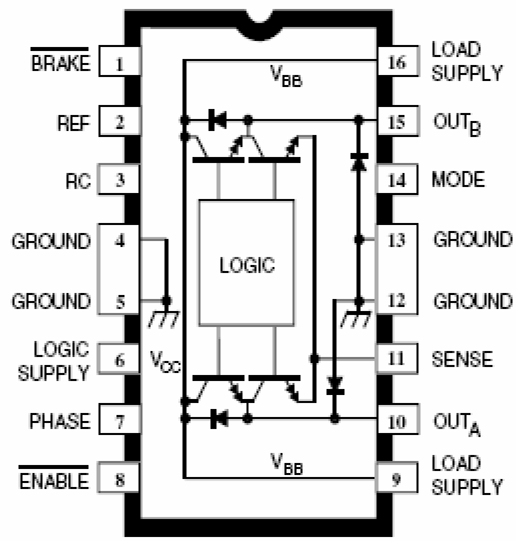

Figure 2.5: A3953 Full-Bridge Driver Pins Configuration

2.4 Dual Motor Bidirectional Electronic Speed Control

It describes an electronic speed control designed to drive two DC motors from a 7.2 Volt battery pack to be controlled by a commercial multi channel model radio control system. Conceived for a tank-like vehicle, one motor drives the left side wheels and the other motor drives the right side. There is a left-rightsteering input and a forward-backward throttle input, like would be used on a model car radio unit.

It is designed using analog circuits rather than a micro-controller or FPGA to allow construction with ordinary breadboarding techniques and no specialized device programmers. It will require a good voltmeter and an oscilloscope to perform the initial checkout and calibration. An additional feature of this design is that it can be built in several configurations due to the modularity of the design. It has been configured with separate right and left throttle controls like a bulldozer, and it has been set up with direct wired controls instead of the radio link.

There are 5 major blocks which is:

1. **Radio Interface**. This block converts the pulse width modulated signal from a standard commercial radio control system into two analog control voltages.
2. **Summing Section**. This block converts the steering and throttle signals into control voltages for the right and left motor PWM generators.
3. **PWM Generator**. Converts the control voltages from the previous stage into Pulse Width Modulated digital signals suitable for driving the power sections.
4. **Right and Left Power Sections**. Contain the power FET"s and associated gate drivers to convert digital control signals into motor drive power. The power sections include the delay generation logic although it is shown separately.
5. **Power Supplies**. There is a 5 volt power supply for the electronics and an 18 volt power supply for the FET gate drives.

There are two identical Output Sections, one for the left motor and one for the right. Since two logically inverted control signals are required for each side of an H Bridge, the control signals generated in the PWM generation section are each fed to an inverter. Now have the required 4 control signals for two separate H bridges. We can see that if both transistors on one side of a bridge were turned on at the same time, we would have a direct short to ground. This problem is called shoot- through current and it is a bigger problem than might be expected. Large FET"s like we want to drive our motors with have a lot of capacitance (7400pF) on their gate leads, so it is difficult to switch them on or off quickly. This switching delay makes it very easy to have both FET"s on for a short period of time each time there is a transition from one FET conducting to the other. A LOT of power can go through in that time and it will heat up transistors and cook them very quickly if allowed to happen. For this reason there are delay circuits put in between the logic level control signals and the actual FET Gate Drive IC inputs. These delays cause the gate turn on to be delayed a hundred nanoseconds or so and the gate turn off to be un-delayed.

Electric motors have a large amount of inductance so that when we can switch the current to them off rapidly (PWM) get a large voltage spike. This voltage spike will turn on the body diode in the opposite transistor while it bleeds off the energy stored in the motor‟s inductance. By virtue of the way we are handling the gate control on the FET‟s, we will help get rid of this energy by turning the opposite FET on when we turn one off. This technique is called synchronous rectification. Having excessively long delays on the gate control hinder this effect, making the body diodes carry more of the load.

After the delay circuits, it is necessary to turn logic level signals into FET gate drive signals. The large amount of capacitance seen looking into the gate on a large FET makes this problem. FET‟s require a fairly high gate voltage to turn on solidly, around 10 volts between the gate and source terminals for most of the large ones. System is designed to run on a 7.2 Volt battery pack. In system, there is a separate power supply to generate this higher voltage (about 18 volts) for the gate drives. If this system ran on about 12 volts or higher, we could use a simpler way to get that elevated voltage.

2.5 RS-232 Serial Port

In telecommunications**,** RS-232 is a standard for serial binary data signals connecting between a DTE (Data Terminal Equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used in computer serial ports.

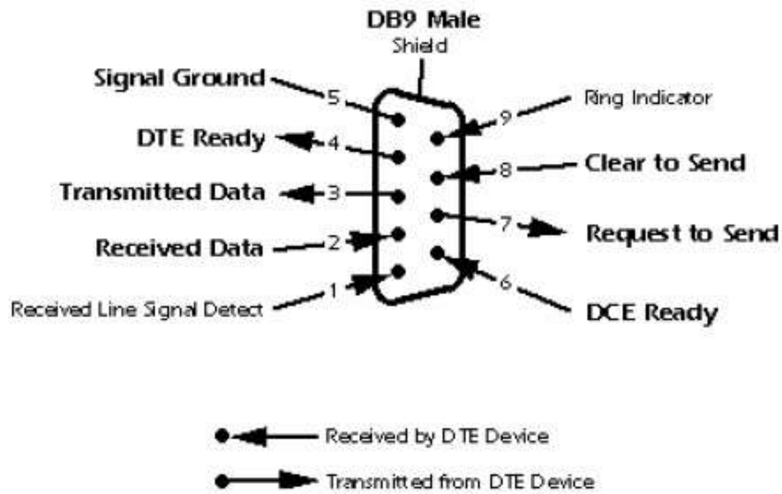

Figure 2.6: DB9 Male Configuration

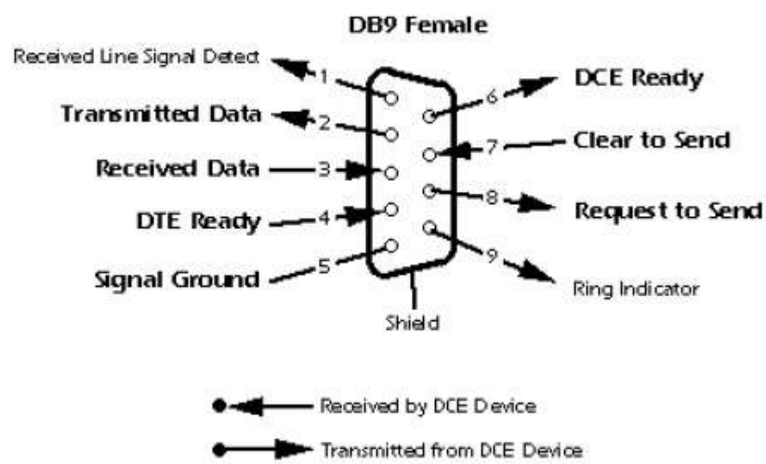

Figure 2.7: DB9 Female Configuration

In RS-232, data is sent as a time-series of bits. Both synchronous and asynchronous transmissions are supported by the standard. In addition to the data circuits, the standard defines a number of control circuits used to manage the connection between the DTE and DCE. Each data or control circuit only operates in one direction that is signaling from a DTE to the attached DCE or the reverse. Since transmit data and receive