DESIGN AND DEVELOPMENT OF AN EMBEDDED CONTROL SYSTEM FOR CONTROLLING A DC MOTOR USING MICROCONTROLLER

MOHAMAD REZDUAN BIN MOHD JAN
B050810149

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Robotic and Automation) with Honours.

by

MOHAMAD REZDUAN BIN MOHD JAN

B050810149

FACULTY OF MANUFACTURING ENGINEERING

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Signature	:	……..
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Date	:	19 MAY 2011

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation) with Honours. The members of the supervisory committee are as follow:

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……

(MOHD NAZRIN BIN MUHAMMAD)

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ABSTRAK

Dalam era teknologi yang moden ini, sebuah sistem elektrik banyak digunakan dalam bahagian elektrik dan elektronik untuk melakukan aplikasi-aplikasi tertentu. Ini adalah sistem yang dibina untuk menyelesaikan dan mengendalikan aplikasi-aplikasi tertentu. Tujuan utama projek ini adalah untuk merancang dan mengembangkan suatu sistem kawalan litar tertanam untuk mengendalikan motor dc menggunakan pengawal mikro. Sebuah sistem tertanam terdiri daripada tiga elemen penting. Salah satu elemen ini ialah mereka sebuah litar. Seterusnya adalah pembangunan dari bahagian kawalan. Untuk projek ini, pengawal mikro dipilih kerana arahan berulang boleh digunakan di dalam pengawal mikro. Untuk mengawal motor arus terus, sebuah elemen dari sistem kawalan PID digunakan. Sistem kawalan PID terdiri daripada Kp, Ki and Kd. Setiap komponen mempunyai tugasnya tersendiri. Kp digunakan untuk meningkatkan tindak balas dalam sesuatu sistem. Nilai untuk Kp boleh diubah untuk mendapat nilai optimum tindak balas dalam sesuatu sistem. Ki pula digunakan untuk mengatasi masalah keadaan mantap. Untuk Kd pula, ia digunakan untuk mendapatkan suatu keadaan yang tepat. Dengan menggunakan PID ini, ubahsuai boleh dilakukan di dalam aturcara untuk mendapatkan suatu kedudukan yang tepat dan betul. Nilai PID ini digunakan untuk meningkatkan tindak balas dan mengurangkan kesalahan dalam sesuatu sistem. Semua maklumat yang berkaitan tentang kaedah untuk mengawal motor arus terus juga telah dibincangkan dalam projek ini.

ABSTRACT

In this modern era technology, an embedded system is widely used in most electric and electronic component for specific task. It is simple systems that are built up for accomplish and control specific task. The main purpose of this project is to design and developed an embedded an embedded control system for controlling a dc motor using a microcontroller. An embedded system consist three important elements during the development. One of the elements is designing a hardware that consist a schematic diagram. Next is the development of the control part. For this project, microcontroller was selected because of the repeated instruction can be used inside the microcontroller. For controlling a dc motor, an element of the control system were added which is PID algorithm. PID algorithm consist three components which is Kp, Ki and Kd. Each component has their own capability for controlling a dc motor. Kp can be used for increase the transient response of dc motor. We can set some values of Kp until get a an optimum system response. For the Ki, it was used for overcome the steady state error. Lastly, Kd is used to get a better response in achieving a set point of the controller by entering a value. By using a PID algorithm, adjusting can be easier by set up in the programming section and the real position of rotation dc motor will get through this programming. This PID algorithm will increase the transient response and reduced the steady state error that exists in the system.

DEDICATION

Firstly, thanks to Allah S.W.T with his blessing, I have done in completing my final year project with succeed. I would apply my gratitude to my father Hj Mohd Jan Bin Udin and my mother Hjh Siti Rahmah Binti Ahmad for giving me a supporting to complete this project. They encourage and inspire me through this project and completing this report. This report is dedicated to my parents of blessed memory, who raise me to be a responsible and careful person. Other than that, I would like to thank to everyone for supporting me in this project.

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PC	–	Personal Computer
DSP	–	Digital Signal Processing
MCU	–	Machine Control Unit
DC	–	Direct Current
PID	–	Proportional Integration Derivative
PCB	–	Printed Circuit Board
OS	–	Operating System
AGC	–	Apollo Guidance Computer
Emf	–	Electro Magnetic Force
PWM	–	Pulse Width Modulation
PIC	–	Programmable Integrated Circuit
ROM	–	Read Only Memory
PV	–	Process Variable
SP	–	Setpoint
CPR	–	Count per revolution
TF	–	Transfer function
PCB	–	Printed circuit board

CHAPTER 1
INTRODUCTION

1.0 Overview

According to the Todd D. Morton, 2001, an embedded system is a computer system designed to perform one or a few dedicated functions often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. By contrast, a general-purpose computer, such as a personal computer (PC), is designed to be flexible and to meet a wide range of end-user needs. Embedded systems control many devices in common use today.

In general, embedded system is not a strictly definable term, as most systems have some element of extensibility or programmability. For example, handheld computers share some elements with embedded systems such as the operating systems and microprocessors which power them, but they allow different applications to be loaded and peripherals to be connected. Moreover, even systems which don't expose programmability as a primary feature generally need to support software updates.

Embedded systems are controlled by one or more main processing cores that are typically either microcontrollers or digital signal processors (DSP). The key characteristic, however, is being dedicated to handle a particular task, which may require very powerful processors. For example, air traffic control systems may usefully be viewed as embedded, even though they involve mainframe computers and dedicated regional and national networks between airports and radar sites. Microcontroller design reflects the constantly changing functional requirements of electronically controlled product. [Greg Osborn, 2010].

Physically, embedded systems range from portable devices such as MP3 players and digital cameras, to large systems like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from very low, with a single microcontroller chip, to very high with multiple microcontroller units with peripherals and networks mounted inside a large chassis or enclosure. In general, embedded system is not an exactly defined term, as many systems can load and run applications. For example, mobile devices share some elements with embedded systems such as the operating systems and microprocessors which runs them but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected like general-purpose computers.

Embedded systems use embedded operating systems which are often real-time operating systems. These operating systems are designed to be very compact and efficient. They leave out many of the functions the embedded computer never uses. 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.

An embedded system is a special-purpose computer controlled electro-mechanical system in which the computer is completely encapsulated by the device it controls. An embedded system has specific requirements and performs pre-defined tasks, unlike a general-purpose personal computer. An embedded system is a computer-controlled system. The core of any embedded system is a microprocessor, programmed to perform a few tasks. This is to be compared to other computer systems with general-purpose hardware and externally loaded software. Embedded systems are often designed for mass production. Embedded systems reside in machines that are expected to run continuously for years without errors. Therefore the software is usually developed and tested more carefully than Software for Personal computers. Many embedded systems avoid mechanical moving parts such as Disk drives, switches or buttons because these are unreliable compared to solid-state parts such as Flash memory.

Figure 1.1 : Embedded system (Heath Steve, 2003)

1.1 Problem Statement

Nowadays, most of the controller has their weaknesses in performing tasks. Some of the problem occurred such as less of efficiency in real time application, didn't get an exactly position and acceleration during rotation of DC motor, and less torque while in rotating position. Due to the problem, an embedded system was develop to increase the efficiency of controller during perform a specific task.

The designer therefore focuses on the controlled object from the beginning to the end of the development and the implementation issues as MCU, the programming language, the scheduling policy and the other nonfunctional aspects.

Through this research, this problem will be overcome with the development of an embedded system and can be implemented in controlling a DC motor with higher efficiency.

1.2 Objective

This project aims to produce an efficient, precise and good DC motor operating system during in embedded system that can be achieved by using a PIC16F877A through a certain programming.

To fulfill the project aim, there are three objectives have been line up and must be achieved. The main purpose of this embedded system is :

1. To design and develop of an embedded control system.
2. To design a PID controller for an embedded system.
3. To get an exact position during rotation of DC motor.

1.3 Scope

This project will mainly focus on development of an embedded system for controlling a DC motor. The following are the guidelines that listed to ensure that the project is conducted within its boundary of hardware modification and development, electronics and programming.

The scope started with hardware modification and development will covered the design of the circuit for an embedded system. This circuit will create in one software. After the development of the circuit was done, all components must be arranged in appropriate position for development of PCB layout. This PCB layout will be used in PCB board for getting a circuit through an etching process.

Next, electronic components must be considered and should attach on the PCB board. After development of circuit was done, programming for the PIC16F877A should be developing using C language. This programming will be downloaded to the PIC16F877A for circuit operations. Through a programming, a torque, position and acceleration of the DC motor can be set up. A DC motor consist an encoder that can be used as a feedback element for controlling a DC motor. Control system element which is PID has been used for adjusting a gain for the encoder while rotating the DC motor.

For scope of testing the project, the circuit must be confirming on their conductivity. This test can be done using a conductive test by using a multimeter. This test can check the conductivity for each component for whole circuit. The circuit must also be tested for its purpose it builds which is for controlling a torque, position and acceleration of the DC motor through a program that has been build in programming section. This test can be done by interfacing the circuit to the computer using USB UART. Several values can be set up in the programming to look on the performance of the torque, acceleration and position of the DC motor.

1.4 Limitation of Project

All projects have their limitation due to its performances and the way it operates for specific task. The limitation for this project is :

a) This embedded system will mainly focus for controlling the position of DC motor.
b) A control system element PID will be attached in this embedded system by adjusting their gain.

1.5 Project Outline

This project consists of six chapters. Chapter one explains the introduction of the project including the objective, scope, problem statement and expected outcomes.

Chapter two describes literature review more about previous study on topics that related to the project. It will cover both, other project research and implementations or organizations that suitable to relate on embedded system.

Chapter three will cover the methodology of the project. The main topic of this chapter will describe the method that is used in development an embedded control system and also the flow chart for the process.

Chapter four illustrates the design and the development. In this chapter, all related designing the project are mentioned such as hardware designing, electronic circuit designing and programming using suitable software.

Chapter five will mainly focus on the result and discussion on the project after the project complete and finally chapter six summarized the project in all field.

1.6 Expected Outcomes

Through this preliminary research, the expected outcome is:

a) Achieve the objective for this project which is design an embedded system for controlling a DC motor.
b) Get an exacted position while rotating a DC motor.
c) Reach a certain value of distances when several values were inserted in a programming.

1.7 Conclusion

From this chapter, all related information has been introduced in development of an embedded system for controlling a DC motor. A general purpose computing system is a combination of generic hardware and general purpose operating system for executing a variety of applications, where an embedded system is a combination of special purpose hardware an embedded OS for executing specific applications. This embedded system was design due to its operation in controlling a DC motor. In designing an embedded system, all related information has been considered such as the hardware, electric and electronic part, programming an element of control system. Embedded systems are designed to serve the purpose of any one or a combination of data collection, storage, representation data communication, data signal processing (DSP), monitoring, control or application specific user interface. The boundary of the development of embedded systems will be discussing more in the next chapter.