



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**STUDY OF SPEED CONTROL FOR AN ELECTRIC
BICYCLE BASED ON PID CONTROL ALGORITHM**

This report submitted in accordance with requirement of the Universiti Teknikal
Malaysia Melaka (UTeM) for The Bachelor of Electronics Engineering
Technology (Industrial Electronic) with Honours

By

MOHD NABIL FIKRI BIN ROSLI

B071310136

901215-07-5295

FACULTY OF ENGINEERING TECHNOLOGY

2016

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Study Of Speed Control for an Electric Bicycle Based on PID Control Algorithm

SESI PENGAJIAN: 2016/17 Semester 1

Saya **MOHD NABIL FIKRI BIN ROSLI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. ****Sila tandakan (✓)**

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

Alamat Tetap:

Cop Rasmi:

Lot 2123-13 kampung Changkat,

Batu 6 $\frac{3}{4}$ Gombak,

53100 Kuala Lumpur Selangor.

Tarikh: _____

Tarikh: _____

**** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.**

DECLARATION

I hereby, declared this report entitled “ Study Of Speed Control For An Electric Bicycle Based On PID Algorithm” is the results of my own research except as cited in references.

Signature:

Name: MOHD NABIL FIKRI BIN ROSLI

Date:

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for The Degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

.....
(Mr Shahrizal Bin Saat)

ABSTRAK

Melaka adalah sebuah negeri tarikan pelancong yang terkenal yang menyediakan perkhidmatan beca di semua kawasan di pusat Bandaraya Melaka. Kita dapat melihat penunggang beca terdiri daripada pelbagai usia. Diantaranya adalah di kalangan orang tua. Mereka mempunyai kesukaran untuk mengayuh beca oleh kerana faktor penumpang yang terlalu berat dan juga kawasan yang berbukit. Mereka juga perlu bekerja lebih keras untuk menjana pendapatan untuk membantu keluarga mereka. Oleh itu, Projek ini di inisiatif untuk membantu penunggang beca untuk mengurangkan tenaga mereka untuk mengayuh beca mereka. Kita tahu bahawa beca diperbuat daripada bahagian basikal. Idea ini adalah untuk mewujudkan sistem gelung tertutup untuk mengawal kelajuan motor DC. Motor DC akan dikawal menggunakan teknik pengawalan PID. Oleh itu, pengawal PID yang akan dilaksanakan untuk DC motor untuk menyelesaikan masalah ini untuk meningkatkan prestasi sistem basikal elektrik ini. Projek ini adalah mengenai mengawal DC motor menggunakan algoritma PID untuk Basikal elektrik. komponen yang paling sesuai untuk mengawal kelajuan basikal ini adalah menggunakan DC motor. Sebab utama menggunakan DC motor kerana DC motor boleh menyediakan kawalan kelajuan yang bagus ,tepat dan kestabilan keseluruhan sistem.

ABSTRACT

As we know, Malacca is a famous tourist attraction state that provided service of trishaw in all area at Centre of Malacca. We can see that some of the trishaw rider is very old enough to rider the trishaw. Additional, the trishaw sometime exhausted to cycle the bicycle because passenger is to weight for cycling the trishaw. They also need to work harder to generate income to help their family. So, we take some initiative to help the rider of trishaw to reduce their energy to cycle the trishaw. We know that trishaw is made from part of bicycle. The idea is to create closed loop system to control the speed of the DC motor. We are tuning the DC motor using PID controller. In a typical electric drive controller, there are usually several nested control loops for the control of current/torque, speed and position, each of which may use a separate proportional integral- Derivative (PID) controller. Therefore, the PID controller will be implemented to DC motor to solve the problem for improve the performance of the system. This project is about controlling DC motor using PID algorithm for Electric Bicycle. DC motors are most suitable for wide range speed control and are therefore used in many adjustable speed drives application. The main reason using DC motor because DC motor can provide the speed control and stability.

DEDICATIONS

To my beloved parents, family members and friends.

ACKNOWLEDGMENTS

In The Name Of Allah, the Most Beneficent and the Most Merciful. A deep sense of thankfulness to Allah SWT who has given me the full strength, ability and patience to complete this Bachelor Degree Project as it is today. Firstly, I would like to take this opportunity to put into words my deepest gratitude and appreciation to my project supervisor, Mr Shahrizal Bin Saat for his support, guidance, patience, encouragement and abundance of ideas during the completion of this project. Secondly, special thanks to both honourable panels, for their comments, invaluable suggestions and outstanding deliberations to improve the project during the project presentation. I would also like to express my extraordinary appreciation to my family especially to my parents, Mr Rosli Bin Abdul Ghani and Puan Rupiza Binti Abdul Hamid and also to my family members for their invaluable support along the duration of my studies until the completion of this Bachelor Degree Project. Finally yet importantly, thanks to my beloved friends who are directly or indirectly contributed due to their supports and guidance and helped greatly to point me in the right direction until the completion of this Bachelor Degree Project

TABLE OF CONTENTS

CHAPTER 1	1
1.0 Background	1
1.1 Problem Statement	2
1.2 Objectives	2
1.3 Project Scope	2
1.4 Project Report Outline	3
CHAPTER 2	4
2.0 Introduction	4
2.1 Introduction controlling DC motor based on PID Algorithm	4
2.2 PID Controller	5
2.2.1 PID controller to produce stability system	6
2.3 DC Geared motor	8
2.3.1 Motor Technical specification	9
2.3.2 DC motor Modelling	9
2.4 Motor Driver	11
2.5 LCD Display 20x4	14
2.6 Potentiometer	15
2.7 Rotary encoder	15
2.7.1 Encoder circuit connection	17
2.7.2 Two Channel Encoder Connection	17
2.8 Arduino Microcontroller	18
2.8.1 Arduino Uno	19
2.9 Different Fuzzy logic controller and PID controller	20

2.10	Previous Work on Modelling a PID controller for DC motor	21
2.10.1	A Modified Design of PID Controller for DC Motor Drives Using Particle Swarm Optimization PSO	21
2.10.2	PID Voltage Control for DC Motor Using MATLAB Simulink and Arduino Microcontroller	22
2.10.3	Speed Control of DC Motor using Pid Controller Based on Matlab	23
2.10.4	Speed Control of DC Motor Using Genetic Algorithm Based PID Controller	23
2.11	Summary	24
CHAPTER 3		25
3.0	Introduction	25
3.1	Project Planning	27
3.2	Project Flow	27
3.2.1	Information Gathering	29
3.3	Testing and Troubleshooting	29
3.4	Conceptual Design	29
3.5	Software and Programming	30
3.5.1	Proteus Software	30
3.5.2	GUI using VISUAL BASIC	33
3.5.2.1	DC Motor Modelling	34
3.5.2.2	Transfer Function for procedure for determining component values	35
3.5.2.3	Parameter Obtain R_a	36
3.5.2.4	Parameter Obtain L_a	36
3.5.2.5	Parameter Obtain K	37
3.5.3	Arduino Software	37

3.6	Hardware Development	38
3.6.1	Hardware prototype design for Electric Bicycle using Arduino UNO	39
3.6.2	Arduino UART to USB connection	39
3.6.3	Arduino Power Supply	40
3.6.4	LCD connection to Arduino	41
CHAPTER 4		42
4.0	Introduction	42
4.1	Project Prototype	42
4.2	Hardware Development and Experimental Works	42
4.3	Software Development and Experimental Works	43
4.3.1	Arduino Programming	44
4.3.2	GUI interface using Visual Basic	46
4.4	Experimental result	47
4.4.1	Open loop system analysis	47
4.4.1.1	Load Disturbance Open-loop system Analysis Data	48
4.4.2	Closed loop system analysis (Static setpoint) using PID controller	50
4.4.2.1	Load Disturbance PID closed loop system Analysis Data	56
4.4.3	Dynamic setpoint Analysis	58
4.5	Overall system Flow	60
4.5.1	Display to Serial Monitor Arduino	60
4.5.2	Display in LCD	61
4.5.3	Transfer data to Excel	62
4.6	Project limitation	63

CHAPTER 5	64
5.0 Introduction	64
5.1 Research of summary	64
5.2 Achievement of Research Objective	65
5.3 Significance of Research	65
5.4 Recommendation	66
5.5 Project Potential	66
REFERENCE	68

LIST OF FIGURES

2.1	Block diagram of Closed loop system	5
2.2	Block diagram of PID controller system	6
2.3	Example Step response graph representing steady-state error , rising time overshootand settling time	7
2.4	Planetary DC Geared Motor (42mm) 14:1	8
2.5	Equivalent circuit for DC motor	9
2.6	DC motor armature control system block diagram	10
2.7	10 Amp Dc motor driver MD 10C	11
2.8	Operation of H Bridge Circuit	13
2.9	LCD Display 20x4	14
2.10	Example connection of LCD display connect with Arduino	14
2.11	Potentiometer 10K	15
2.12	Rotary encoder	15
2.13	Two output from rotary encoder represent two square wave in Quadrature	16
2.14	Arduino circuit connection for encoder	17
2.15	Example of Arduino Board	18
2.16	Basic layout of Arduino UNO microcontroller	19
3.1	Planning of speed control for an electric bicycle based on PID control algorithm Phase	25
3.2	Step of Methodology	26
3.3	Project Process Flowchart	28

3.4	Illustration design for the system	30
3.5	Interface feature in Proteus Software	31
3.6	Arduino UNO connection pin in Proteus	31
3.7	Motor Circuit connection pin in Proteus	32
3.8	Analog Input/Potentiometer Circuit connection pin in Proteus	32
3.9	Digital Input/Push Button Circuit connection pin in Proteus (prototype)	32
3.10	Display Circuit connection pin in Proteus	33
3.11	GUI interface using Visual Basic	34
3.12	DC motor modelling schematic	34
3.13	Arduino Interface Software	38
3.14	Prototype of design for Electrical bicycle using Arduino	39
3.15	Connection UART to USB using Arduino	39
3.16	Arduino UNO supply	40
3.17	LCD connection to Arduino UNO	41
4.1	Connectivity of Arduino UNO, DC motor, LCD display and rotary Encoder	43
4.2	Code PID tuning value	44
4.3	Code of declaration of RPM, PID value and LCD display	45
4.4	Visual Basic For Prototype of an electric bicycle	46
4.5	Controlling the speed of DC motor using Potentiometer (PWM)	47
4.6	Controlling the speed of DC motor in Percentage	47
4.7	Controlling PWM value and The Output value of DC motor	48
4.8	Graph for Testing Load disturbance for setpoint 100 rpm	48

4.9	Graph for Testing Load disturbance for setpoint 150 rpm	49
4.10	Graph for Testing Load disturbance for setpoint 200 rpm	49
4.11	PID tuning $K_p=0.05$, $K_i=0.05$ and $K_d=0$	50
4.12	Output value for $K_p=0.05$, $K_i=0.05$ and $K_d=0$	50
4.13	PID tuning $K_p=0.10$, $K_i=0.05$ and $K_d=0$	51
4.14	Output value for $K_p=0.10$, $K_i=0.05$ and $K_d=0$	51
4.15	PID tuning $K_p=0.010$, $K_i=0.05$ and $K_d=0$	52
4.16	Output value for $K_p=0.010$, $K_i=0.05$ and $K_d=0$	52
4.17	PID tuning $K_p=0.010$, $K_i=0.10$ and $K_d=0$	53
4.18	Output value for $K_p=0.010$, $K_i=0.10$ and $K_d=0$	53
4.19	PID tuning $K_p=0.010$, $K_i=0.3$ and $K_d=0$	54
4.20	Output value for $K_p=0.010$, $K_i=0.3$ and $K_d=0$	54
4.21	PID tuning $K_p=0.010$, $K_i=0.3$ and $K_d=0.01$	55
4.22	Output value for $K_p=0.010$, $K_i=0.3$ and $K_d=0$	55
4.23	Load are been apply in real time application	56
4.24	Testing closed loop using load disturbance 0.25 KG	57
4.25	Testing closed loop using load disturbance 1.5 KG	57
4.26	Testing closed loop using load disturbance 2.5 KG	57
4.27	Dynamic setpoint analysis 1 using PID parameter: $K_p=0.010$ $K_i=0.3$ and $K_d=0$	58
4.28	The output value for parameter $K_p=0.010$, $K_i=0.3$ and $K_d=0$	59
4.29	Dynamic setpoint analysis 2 using PID parameter: $K_p=0.010$, $K_i=0.3$ and $K_d=0.01$	59
4.30	The output value for parameter $K_p=0.010$, $K_i=0.3$ and $K_d=0$	60
4.31	Display of the Serial Monitor in Arduino	61
4.32	LCD display for the open loop system	61

LIST OF TABLES

2.1	DC geared motor technical specification	9
2.2	Absolute Power Maximum for Motor Driver MD 10C	12
2.3	Connection motor and power Source	12
2.4	Motor Encoder technical specification	17
2.5	Arduino UNO Technical Specification	20
3.1	Description of state variable based on equivalent motor transfer function	35
4.1	Summarize of experiment take out to find optimum parameter for PID controller	56
4.2	Data sent to Excel	62

LIST OF SYMBOLS AND ABBREVIATIONS

DC motor	=	Direct Current motor
PID	=	Propotional Integral Derivative
T_r	=	Time rising
T_s	=	Time Setling
$\%_{sse}$	=	Steady state error
K_p	=	Propotional Gain
K_i	=	Intergral Gain
K_d	=	Derivative Gain

CHAPTER 1

INTRODUCTION

1.0 Background

DC motors is the most reasonable for a widespread range, velocity control and are thus applied in many adaptable speed drives applications. The primary reason to apply a DC motor because DC motor can provide the speed control and stability [1]. DC motor has at the torque and speed qualities well-disposed with most mechanical burdens. The speed control techniques for a DC motor are anything but difficult to utilize and less expensive than those of AC motor and speed control over a wide range both upper and lower evaluated speed can be less demanding to accomplished. In an exemplary electric drive controller, there are generally a few settled control circles framework for the predominance of current or torque, speed and position, each of which may utilize a solitary corresponding essential Derivative (PID) controller. Although DC motor is much stable than AC motor, they establish that there has some unstable performance of a DC motor in an early phase [2]. The overshoot and undershoot will occur after starting playing the DC motor. This position will lessen the accuracy and functioning of the applications. Beside than the overshoot problem, high rise time, T_r , settling time, T_s and steady state error will also diminish the functioning of the organization [3]. Therefore, the PID controller will be implemented to DC motor to solve the problem for improved the performance of the system.

1.1 Problem Statement

1. Trishaw riders carry a heavy customer to generate their income to help their family.
2. Trishaw riders have to climb up the slope and hilly to reach the destination that been deal with passenger.
3. Trishaw rider exhausted to cycle the Trishaw.

1.2 Objectives

1. To design a closed-loop system for DC motor that be controlled using PID to easy the trishaw rider for carry heavy load.
2. To create a PID controller for the purpose of controlling the speed of DC motor.
3. To create a hardware for the DC motor with input paddle for real implement.
4. To reduce air pollution and create green technology product.

1.3 Project Scope

This project is done on Hardware and Software. The software that been used is Arduino UNO. It delivers 14 digital input and output pins. It either be use as PWM output. The parameter of the PID can be tune using Matlab/Simulink or manual adjusting in prototype, The Parameter will be program by using Arduino language. The Arduino is use to drive the speed of DC motor. The Arduino is the easy program to control the plant that we want. The Hardware that use is a DC motor. The DC motor is controlled by using Arduino UNO. The input on this project is a Paddle reading by rotary encoder. The Paddle will oscillate by the rider to trigger the DC motor. The rider only has to paddle only a certain RPM. The amount RPM that we set will be the speed of the DC motor.

The Software that be use is graphical user interface (GUI) using Visual basic. .The function of GUI to display the output from Arduino microcontroller. The graph is

display using Zed graph plot in visual basic to display Real time setpoint and Actual speed for the system. The value for setpoint and actual speed is also display in the GUI.

1.4 Project Report Outline

This project report is separate to five sections. The main part are talked about and briefly on the framework software and hardware utilized as a part of this venture alongside the goals and extents of the venture. A few literary works and past examines with comparable title have been checked on in Chapter 2. Part 3 clarified points of interest on the strategy and execution stream of this project. Every one of the results and aftereffects of this venture are talked about in Chapter 4. Lastly on Chapter 5 synopsis of conclusions and future works are introduced.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this segment it will talk about the literature, talk and see of past examination and some meaning of the parts utilized as a part of this project for example, Arduino microcontroller, DC motor demonstrating and other. Through the world, there have various diverse sources and investigates about the idea, plan and usage of the Arduino to control DC motor utilizing PID control calculation. It additionally contained the examination of what others have done in this section. This review incorporated the hardware and software development. Writing audits are based on data that got from various sources, articles, specialized reports, general reports, sites, books and individual correspondence.

2.1 Introduction controlling DC motor based on PID Algorithm.

PID controller is a typical control circle input controller broadly practiced in numerous application control system. PID is the most usually utilized input controllers. Figure a mistake value as the conflict between a measured process and a desired setpoint. The controller tries to minimize the error by revising the procedure control input. The PID controller estimation (calculation) includes three steady parameters called the proportional (P), Integral (I) and Derivative (D) values, these qualities can be comprehended as far as time. P relies on upon the present error, I on the gradual addition of past error, and D is a prognosticating of future error, in view of current rate of adjustment [4]. The weighted aggregate of these three parameter is utilized to set

the system through a control component, for example, the area of a control valve, or power provided to a heating component.

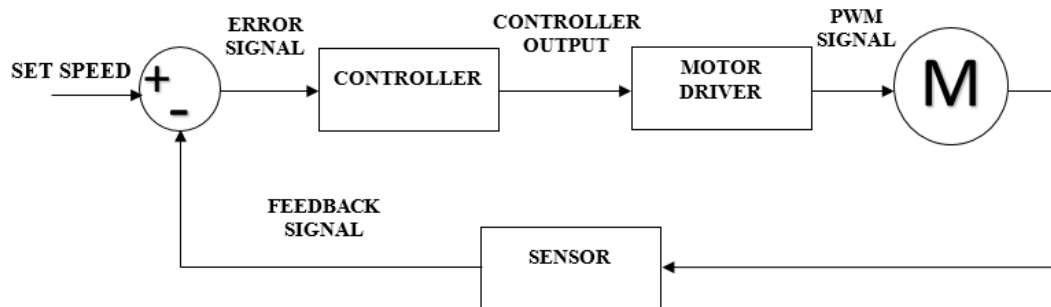


Figure 2.1: Block diagram of closed loop system.

In this project, we are controlling the speed of a DC motor in PID parameter utilizing Arduino UNO. This microcontroller is a best decision for this project since its simple and environment client encounter, Arduino has been utilized as a part of a large number of various activities and applications. The Arduino writing computer programs is definitely not hard to-use for novices, yet adequately versatile for bleeding edge customers. Educators and researcher similarly utilize it to make negligible exertion legitimate instruments, to show science and material science guidelines, or to initiate annoyed out with programming and mechanical innovation. Inside decorators and architects build savvy models, entertainers and pros use it for foundations and to attempt distinctive things with new melodic instruments.

2.2 PID Controller

DC motor is an actuator that changes electrical vitality to a mechanical Energy. It likewise are controlled over an across the board go with solidness and straight attributes [5]. The advantage of DC motor might be speed control. The term speed control remain for deliberate speed variety completed consequently and physically. DC engines are practically suited for a wide range, speed control and are in this way connected in numerous flexible speed drives. Since speed is specifically relative to armature voltage and conversely corresponding to attractive flux made by the shafts

and altering the armature voltage or potentially the field current will move the rotor speed. In the meantime PID controller has some advantage, specifically, the undesirable speed overshoot and the ease back reaction because of sudden change in load torque and the affectability to controller picks up K_I and K_P [6] . The operation of this shut circle controller relies on upon the exactness of framework models and parameters. Consequently there is a request of a controller which can settle shortcomings of PID controller.

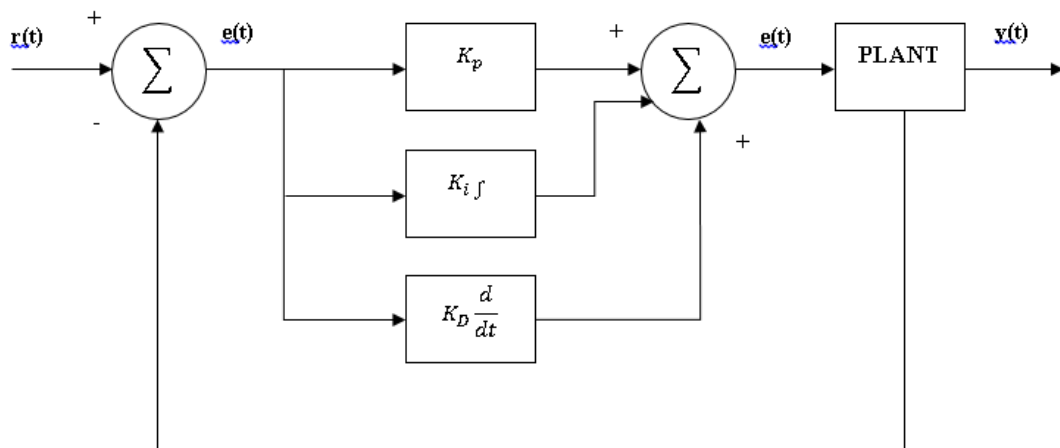


Figure 2.2: Block diagram of PID controller system

2.2.1 PID controller to produce stability system

In this project, DC motor speed control is developed by the PID controller. The performance measure to be minimized contains the following objectives of the PID controller:-

1. Minimum the steady state error, the change between the input and output of the system in the edge as time goes to infinity. For example when the transient response reaches a steady state. With no overshoot the steady state error is rejected when the steady state velocity of the DC motor makes the desired speed,