

VSS APPROACH TO DC MOTOR DRIVES

NUR ASYRANI HANIS BINTI SAMSUDIN

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NUR ASYRANI HANIS BT. SAMSUDIN

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“I hereby declared that I have read thought this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drives)”

Signature :



Supervisor's Name :


Mr. Hyreil Anuar Bin. Hj. Kasdirin

Date :

May 2007

HYREIL ANUAR BN HJ KASDIRIN
Pensyarah
Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka.

“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 : NUR ASYRANI HANIS BINTI SAMSUDIN

Date : MAY 2007

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ABSTRACT

The Direct Current (DC) motor speed (ω) or current (I) controls based on Variable Structure System (VSS) is presented in this thesis. It deliberates about the introduction the Sliding Mode method to produce a good dynamic and steady state behavior of the DC motor drive. Switching function estimation mode which is based on the control error of speed and armature current information is being discussed. Furthermore, the external torque which is unmeasurable can be estimated by using the information from current and speed. In additional, it also shows the comparison Proportional Integral (PI) control and Sliding Mode Control (SMC). The simulation result of the SMC show that system motion is as it was predicted from theoretician analysis.

TABLE OF CONTENTS

CHAPTER	CONTENTS	PAGE
	TABLE OF CONTENTS	viii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF SYMBOLS	xv
	LIST OF APPENDICES	xvii
I	INTRODUCTION	1
	1.1 OVERVIEW	1
	1.2 OBJECTIVES	3
	1.3 SCOPE OF PROJECT	4
	1.4 RESERCH METHODOLOGY	5
	1.5 THESIS LAYOUT	7
II	DC MOTOR DRIVES	9
	2.1 DC MOTOR DRIVES	10
	2.1.1 Modeling DC Motor	13
	2.1.2 DC Motor Modelling Using MATLAB/Simulink	15
	2.1.2.1 MATLAB/Simulink	15
	2.1.2.2 Method to Create DC Motor Model	16
	2.1.2.3 Simple Simulation of DC Motor	17
	2.2 SUMMARY	21

III	SLIDING MODE CONTROL (SMC) DESIGN	22
3.1	SLIDING MODE CONTROL (SMC)	23
3.2	OVERVIEW THE SLIDING MODE CONTROL THEORY	24
3.2.1	Basic of Variable Structure System Approach	24
3.2.2	Switching Functions Torque or Current Control	25
3.2.2.1	Design Torque or Current Control	26
3.2.2.2	Simple Simulation of SMC	26
3.2.3	Switching Function of Speed	28
3.2.3.1	Design Speed	29
3.2.3.2	Simple Simulation of SMC	29
3.2.4	Luenberger Estimation of Load Torque (T_L)	31
3.2.4.1	Why Need Estimation T_L	31
3.2.4.2	Luenberger Estimation	31
3.3	SUMMARY	33
IV	PROPORTIONAL INTERGRAL (PI) CONTROLLER DESIGN	34
4.1	PROPORTIONAL INTEGRAL (PI) CONTROLLER	35
4.2	DESIGN OF PI CONTROL	35
4.3	SUMMARY	38

V	SIMULATIONS AND RESULTS	39
	5.1 SIMULATION RESULT	40
	5.1.1 Sliding Mode Controller (SMC)	40
	5.1.1.1 Torque Control (σ_τ)	40
	5.1.1.2 Speed Control (σ_ω)	42
	5.1.1.3 Luenberger Estimation	43
	5.1.2 Proportional Integral (PI) Controller	44
	5.1.2.1 Torque Control for PI Controller	44
	5.1.2.2 Speed Control for PI Controller	44
	5.1.3 Comparison between SMC and PI Controller	45
	5.1.3.1 Torque Control	45
	5.1.3.2 Speed Control	46
	5.1.3.3 Load Disturbances	47
	5.2 SUMMARY	49
VI	CONCLUSION AND RECOMMENDATIONS	50
	6.1 CONCLUSION	50
	6.2 RECOMMENDATIONS	51
	REFERENCES	52
	APPENDIX A	53
	APPENDIX B	54
	APPENDIX C	55
	APPENDIX D	56

LIST OF TABLES

NO	TITLE	PAGE
2.1	Parameters of DC Motor	18
3.1	DC Motor Parameters for Torque SMC	26
3.2	DC Motor Parameters for Speed SMC	29
5.1	Parameters of DC Motor for Comparison	40

LIST OF FIGURES

NO	TITLE	PAGE
1.1	Flow Chart of Methodology Project	6
2.1	Model Direct Current (DC) Motor	10
2.2	Rotor Part of Direct Current (DC) Motor	11
2.3	Structure Direct Current (DC) Motor	12
2.4	General Arrangement for Variable Speed Drives	13
2.5	Equivalent Circuit	13
2.6	Block Diagram of DC Motor	15
2.7	Flow Chart of DC Motor Model	16
2.8	MATLAB/Simulink File of DC Motor Simulation	17
2.9	The Setting of Blocks Parameters	18
2.10	Simulink Parameters Block	19
2.11	Result for Simulink	20
3.1	Block Diagram of System	23
3.2	Block Diagram Torque or Current Control	25
3.3	Diagram Torque or Current Control	26
3.4	Result Torque for Torque Control	27
3.5	Result Speed for Torque Control	27
3.6	Block Diagram Speed Control	28
3.7	Diagram Speed Control	29
3.8	Result Speed of Speed Control	30
3.9	Result Torque of Speed Control	30
3.10	The Block of a Luenberger Observer of the Load Torque	32
3.11	The Structure of a Luenberger Observer of the Load Torque	32
4.1	The Design of PI Controller	35

4.2	Current Loop	36
4.3	Speed Loop	36
4.4	Speed and Current Loop	37
5.1	Results Torque for Torque Control	41
5.2	Results Spéed for Torque Control	41
5.3	Result Speed for Torque Control, (tr.1) ω and (tr.2) ω^*	42
5.4	Result Torque for Torque Control	42
5.5	Result Luenberger Estimation	43
5.6	Result Torque for Torque Control, (tr.1) T and (tr.2) T^*	44
5.7	Result Speed for Speed Control, (tr.1) ω^* and (tr.2) ω	44
5.8	Result Torque for Torque Control (tr.1) T^* and (tr.2) T for PI Controller and (tr.3) T for SMC	45
5.9	Result Speed for Speed Control, (tr.1) ω^* and (tr.2) ω for SMC and (tr.3) ω for PI Controller	46
5.10	Results for Load Disturbance (1) Speed Reference, (2) PI, (3) SMC & (4) Torque Load	47
6.1	Suggestion Hardware for Torque Control	51

LIST OF SYMBOLS

- θ : The shaft position, (rad)
- ω : The speed of the shaft and the load
(angular velocity), (rad/s)
- T : The torque motor, (Nm)
- T_L : The load torque, (Nm)
- i_a : The armature current, (Amp)
- B : The damping ratio of mechanical system, (Nms)
- L_A : The armature inductance, (H)
- R_A : The armature resistance, (ohm)
- J : The moment inertial of the motor rotor and load,
(kg.m²/s²)
- K_T : The torque factor constant, (Nm/Amp)
- K_E : The motor constant, (v - s/rad)
- U_d : The input voltage, (V)
- U_A : The back emf, (V)

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Robust Control of DC Motor Drive	53
B	Sliding Mode Variable Structure Control Design Principles and Application to DC Drives	54
C	VSS Approach to DC Drives Control	55
D	A Control Engineer's Guide to Sliding Mode Control	56

CHAPTER I

INTRODUCTION

1.1 OVERVIEW

In industry, Direct Current (DC) motor is an important part to control variable such as speed (ω), torque (T), position (θ) and armature current (i_a). Examples of industrial equipment that use DC motor are conveyer, robot arm and DC switching power converter. However, the problem that arise when using DC motor are steady state error, low response and high percentage overshoot. For solving this problem, a Proportional Integral (PI) controller was designed but PI controller is very sensitive to the controller gains proportional and integral [4]. As a result, Sliding Mode Control (SMC) technique appeared to solve this DC motor problem [3]. SMC is very suitable because it is insensitive to system parameter variations, making very attractive for excellent performance and easy implementation [5]. For speed and current, it can be controlled accurately by using a simple control algorithm.

This thesis explains about robust control of DC motor drive using Sliding Mode Control (SMC). First, the switching function constructed based on the error between references and actual of the controlled variable such as torque and speed. To get an estimation load torque, a simple estimation using Luenberger Observer will also be discussed [5]. The robustness of the system using SMC is verified by comparing the performance of the system with a DC motor drive using PI controller. The design of the

system and performance analysis are performed using SIMULINK-MATLAB. At the end, simulation result are presented for the improved theory.

1.2 OBJECTIVES

The objectives of this research are as follows:-

- i. To control Direct Current (DC) motor on its speed (ω) and torque (T) to reduce robust control, fast transient response, minimum overshoot and good dynamic response using Sliding Mode Control (SMC).
- ii. To simulate DC motor speed control and torque control using MATLAB/Simulink.
- iii. Compare between Proportional Integral (PI) control and SMC method to get the best controller for DC motor.
- iv. To estimated load torque (T_l) of the drive using Luenberger Estimation.

1.3 SCOPE OF PROJECT

The work undertaken in this project is limited to the following aspects:

- i. To design a proper controller (Sliding Mode Control) for torque (T) and speed (ω) control of Direct Current (DC) motor.
- ii. Simulation work using MATLAB/Simulink as a platform to prove the effectiveness of designed controller.
- iii. The Sliding Mode Control (SMC) will be designed as described in Asif Sabanovic (1988) and Auzani Jidin (2004) [3] [5].
- iv. The Proportional Integral (PI) control will be designed to compare performance with SMC.
- v. Luenberger Estimation methods have been implemented to estimate load torque.

1.4 RESEARCH METHODOLOGY

The research work is undertaken in the following this section:

- i. The literature reviews important to get information, materials and data for this research. Many materials will be used for get information about thesis such as paper, journal, books and internet.
- ii. Study and understand about Direct Current (DC) motor characteristic as a guideline to design block for DC motor.
- iii. Design of a Sliding Mode Control (SMC) for torque and speed control of DC motor.
- iv. Perform simulation for SMC torque and speed in DC motor drives.
- v. Design and perform simulation for load torque using Luenburger Estimation. Comparison results SMC with Proportional Integral (PI) control.
- vi. Design of a Proportional Integral (PI) control for get performance of speed and torque using MATLAB/Simulink.
- vii. Performances of the SMC and PI Control will be comparing to get best controller.

1.5 THESIS LAYOUT

The rest of the project's chapters are organized as follows:

Chapter 2 review the basic of Direct Current motor (DC motor) theory along with the modeling of DC motor and its equivalent transfer function or equation. Beside, this chapter will explain the method to make simulation from designing block DC motor until getting the relevant result. The modeling and equation of DC motor have already been explained well. The DC motor needs a controller to produce a good performance. The basic at DC motor was designed to use at simulation for Sliding Mode Control (SMC) and Proportional Integral (PI) controller. The Sliding Mode Control (SMC) will discuss in the Chapter 3 to continue this thesis.

Chapter 3 gives overview about Variable Structure Systems (VSS) using Sliding Mode Control (SMC). Speed control (ω) and torque control (T) technique are briefly reviewed to give an ideal of the concept and the need for a robust. This chapter, SMC were designed and mathematically proven. The design of speed control (σ_ω) and torque control (σ_T) are discussed at this chapter. The SMC equations extensively used for estimation load torque (T_L) are designed. PI controller will be discussing at the next chapter.

Chapter 4 discuss about PI controller to get speed (ω) and torque (T) performance. This chapter will be discussed how the PI controller values are determined, the transfer function and the layout of overall system are viewed. After the speed loop and torque loop was designed, the overall of the PI controller loop will be designed. PI controller performance will be compared with Sliding Mode Control into Chapter 5.

Chapter 5 reviews main point for this research, about comparisons between Sliding Mode Control (SMC) with PI control. The simulation results create using MATLAB/Simulink. The Variable Structure System (VSS) using Sliding Mode Control

(SMC) is a robust control that will give an excellent performance and could control speed (ω) or torque (T) accurately for Direct Current (DC) motor. The objective of this chapter is to compare the Proportional Integral (PI) controller with the Sliding Mode Controller (SMC) for DC motor control. Comparison of both controllers was discussed in this chapter and it shows that SMC performance better than PI controller. The PI controller system was very sensitive. The objectives have been achieved for get best controller.

Chapter 6 gives summarizes and recommendations for future work to continue of this project are presented at the end of the chapter.

CHAPTER II

DC MOTOR DRIVES

In this chapter, the basic of Direct Current motor (DC motor) theory will be reviewed along with the modeling of DC motor and its equivalent transfer function or equation. It is important to understand the basic of DC motor because DC motor is a main part in this thesis. Those parts are essential to understand the electric drive. Beside, this chapter will be explaining the method to make simulation from a design block DC motor. In addition, this chapter will be introducing about MATLAB/Simulink as an important simulator to produce the result needed.