VSS APPROACH TO DC MOTOR DRIVES

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MAY 2007

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree of Bachelor In Electrical Engineering (Power Electronic and Drives)

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May 2007

"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)"

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Date : MAY 2007

To my dearest father, Mr. Samsudin Hj. Mohd Nor and brothers, Asmu'i and Aimullah for their encouragement and blessing. Special to my supervisors, Mr Auzani Jidin and Mr. Hyreil Anuar Kasdirin for their fully support and caring from PSM 1 until PSM 2. To my entire beloved classmate for supported.

ACKNOWLEDGMENT

Alhamdulillah, thankful to Allah s.w.t for the smooth progress of my PSM thesis. Firstly, I would like to take an opportunity to express my deepest gratitude to my supervisor Mr. Hyreil Anuar Bin Hj. Kasdirin and Mr. Auzani Bin Jidin because they willing to accept and teach me along this project till finished. Without them maybe this thesis will not complete.

Beside thanks to the PSM panels Dr. Ismadi Bugis and Ir. Rosli Bin Omar. Also I would like to say thank to my beloved friends for cooperation and sapporting me. Not forgetting my dedication to my members of academic and technical staff of FKE UTeM that guiding me directly or indirectly to complete this thesis.

Last but not least, special thanks to my beloved dad (Samsudin Bin Hj. Mohamad Nor) for supporting me morally and financially during this project been implemented.

Thank you all.

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.

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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.m^2/s^2)
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)

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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 effectives 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.

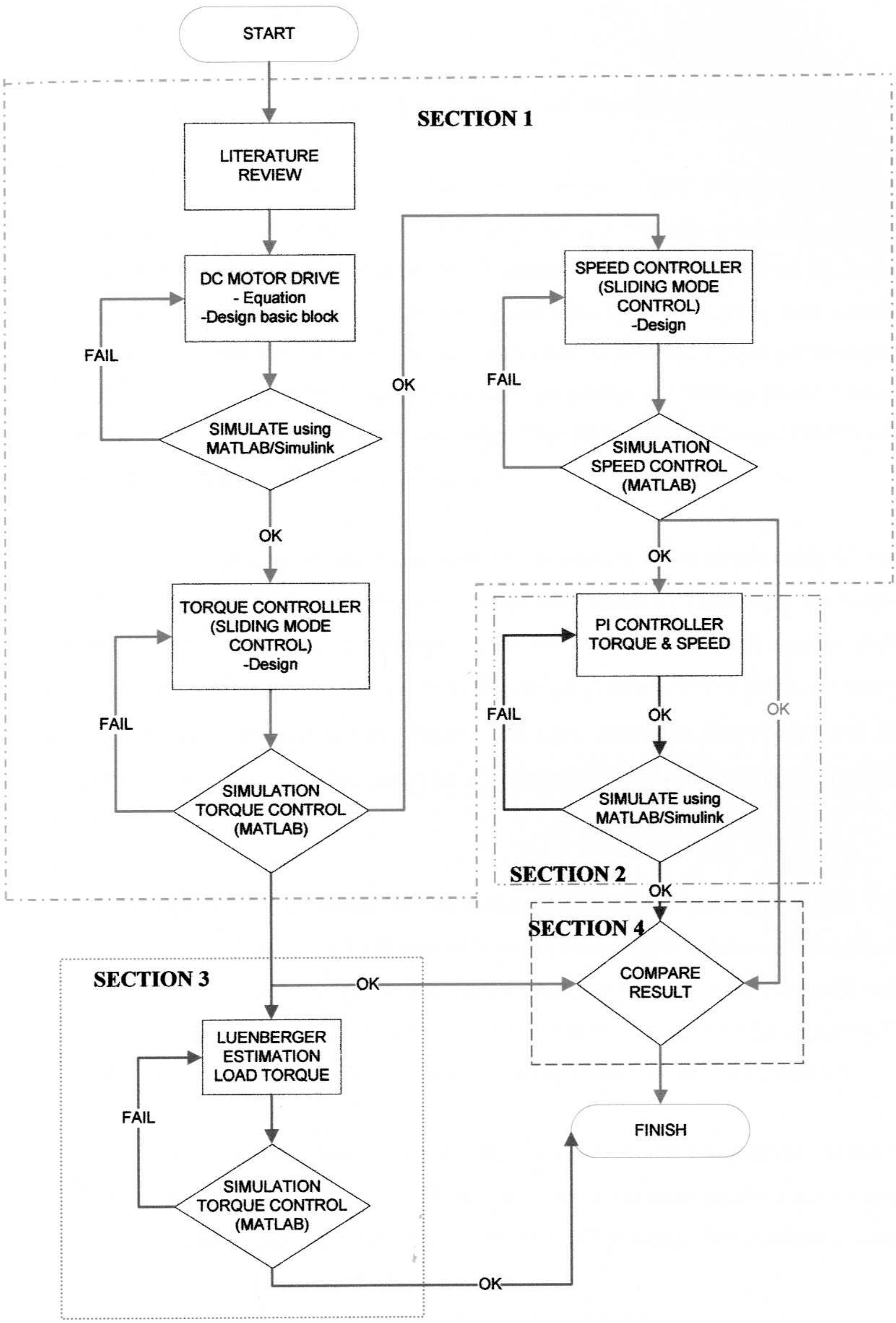

Figure 1.1: Flow chart of methodology project

1.5 THESIS LAYOUT

The rest of the project's chapters are organized are 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.