AN APPLICATION OF OBSERVER FOR POSITION SENSORLESS STEPPER MOTOR DRIVES

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This project report submitted in partial fulfilment of the requirements
for the award of the degree of Master of Engineering
(Electrical - Mechatronics and Automatic Control)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

NOVEMBER 2009

Dedicated with deepest love to:

My family, parents and siblings for their support, guidance and love.

My dearest friends for being there whenever I needed them.

ACKNOWLEDGEMENT

In the name of ALLAH, the Most Beneficent, The Most Gracious and the Most Merciful who has given me persistence in completing the project.

First of all, I would like to express my sincere gratitude to my project supervisor, Dr Salinda Buyamin, for the commitment, encouragement and valuable advice she provided me along the entire course of this project and report. Her rigorous views to do the project and inspire the idea to solve problems are precious for my future career.

I wish to thank my lab mates at Process Control Laboratory , Mr Alifa, Mr Rozaimi and Mr Azuni from Advanced Machine laboratory for the intellectual input and technical assistance .

I would like to thank to my colleague members, from MEM class of 2008/09 session for their support and advice.

A special thanks to my department, Malaysian Nuclear Agency who gives me the opportunity to continue my study.

ABSTRACT

A control method for stepper motor drives system can be made in open-loop circumstance which mean the system control did not require any feedback input signal in order to run the system. By applying the right sequences of pulses, the stepper motor capable to operate as other motion control. However, the performance of such system cannot be achieved to high level condition and demanded a feedback signal input to compensate the error produced while running the drive system. Therefore, a physical sensor or an encoder is placed in the motor system to obtain the feedback and form a close-loop system for error compensation. Nevertheless, the prices of these instruments are expensive, bulky and also may degrade the system performance. As a result this project presents a sensorless system in stepper motor drive system as an alternative to develop a close-loop system where the input signals are taken from voltage and current of the magnetic flux of the stepper motor.

ABSTRAK

Kaedah kawalan sistem motor stepper boleh dijalankan dalam keadaan lingkaran terbuka iaitu bermaksud sistem kawalan tidak memerlukan apa-apa suapbalik signal masukan semasa operasi dijalankan. Dengan mengaplikasikan urutan denyutan yang betul, stepper motor mampu beroperasi seperti kawalan gerakan yang lain. Walaubagaimanapun prestasi tersebut tidak boleh mencapai pada tahap yang tinggi. Ini memerlukan suapbalik masukan untuk mengimbangi kesilapan semasa sistem pemanduan beroperasi. Dengan itu, alat pengesan atau encoder diletakkan dalam sistem motor untuk menghasilkan suapbalik dan seterusnya membentuk sistem lingkaran tertutup sebagai pengimbangan kesilapan. Akan tetapi, harga alatan ini adalah mahal, bersaiz besar and juga boleh mengurangkan prestasi sistem. Oleh itu, projek ini mengetengahkan satu sistem tanpa alat pengesan dalam sistem pemanduan motor stepper sebagai alternatif membentuk sistem lingkaran tertutup di mana signal masukan diambil dari voltan dan arus magnetik fluk yang dihasilkan oleh stepper motor.

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LIST OF ABBREVIATIONS

ADC	-	Analog to Digital Converter
BCD	-	Binary Coded Decimal
CCW	-	Counter Clock Wise
CW	-	Clock Wise
DC	-	Direct Current
DIR	-	Direction
DMOS	-	Double-diffused Metal Oxide Semiconductor
DQ	-	Direct Quadrature
DSP	-	Digital Signal Processing
FPGA	-	Field- Programmable Gate Array
GS	-	General Structure
HSM	-	Hybrid Stepper Motor
IPM	-	Interior Permanent Magnet
LTI	-	Linear Time-Invariant
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
MRAS	-	Model Reference Adaptive System
MSU	-	Microcontroller
PC	-	Personal Computer
PID	-	Proportional Integral Derivative
PLC	-	Programmable Logic Control
PM	-	Permanent Magnet
PWM	-	Pulse Width Modulated
UIO	-	Unknown Input Observer
VHDL	-	Very High-level Design Language
VR	-	Variable Reluctance

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CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, a real robust of motion control in mechatronics technique is required in a very precise positioning and broad speed range applications. It means that drive systems are robust-controllable for precise positioning and broad speed range including from an ultra small to large positioning and ultra low to ultra high speed range. Both speed and positioning controller is very important for the performance improvement of drive systems. One of the important motion controls is to design a self reconfigurable controller such as electric motor controller for a hybrid electric vehicle application. This system detects the current sensors failure and will estimate the current successfully such that the motor continues working safely. The motor model is used for estimating the currents and the phase are estimated using Luenberger observer. The hall sensors with 60 degrees resolution have been used for positioning sensor. [1].

Nowadays, the emerging control applications become advance as a power assisting tools. An example is a power-assisted wheelchair where a controller is considering necessary conditions for power assisting tools. For advanced controls of a power-assisted wheelchair, the control for speed of power assisting motors is needed. One of the features of a wheelchair is operating at very slow speed and even stops frequently. Thus, an instantaneous speed observer is necessary for the control of a power-assisted wheelchair since the instantaneous speed observer has fast convergence speed, and applies it to gravity compensation controller of a power-assisted wheelchair especially when it goes on a hill [2].

Observer also called a sensorless system is a popular application in motion control where the physical sensor such as encoder will not be used to obtain the system feedback. Besides be able to remove space allocation for rotation-sensor hardware, it also is able to eliminate mechanical adjustment and maintenance. The other applications of the sensorless system are in city-scooter application, which has been design of a sensorless scheme suitable for general applications where low speed and standstill such as high speed operations are required. The observer detects the rotor magnet flux components in the two-phase stationary reference frame using the motor electrical equations [3]. The observer also used in solving the speed estimation problem in high-power railway traction applications, including the very low speed range. The full-order Luenberger observer design, based on voltage and current models, is used as the optimal alternative instead of the conventional method based on observer pole placement. [4].

1.2 Problem statement

Recently, there has been an increase attention of drives system in positioning applications. This increasing is attributed of the developments in power electronics and computing technology. Together with faster computing capabilities, the complex calculations can be performed in a shorter period of time. These advances have opened up new opportunities for advanced control methods such as in nonlinear and optimal control. Moreover, a self-tuning and adaptive methods which used to determine unknown or slowly varying parameters are capable of adjusting the control system to maximize performance with minimal or no operator intervention automatically [1]. In motion control, accurate speed and positioning information is necessary to realize high performance and precision control. Many techniques were developed to achieve speed and positioning including mechanical sensors such as shaft encoder or a resolver. Nevertheless, the prices of these instruments are expensive, bulky and degrade the system. Therefore, a sensorless motion control is developed to replace the hardware part [5].

1.2 Objectives of the project

The objectives of the project are determined as:

i) To investigate the performance of position control of stepper motor using PIC controller

ii) To study the application of sensorless in position control system of stepper motor

1.3 Scope of the project

The scope of the project includes:

i) To construct the hardware for stepper motor drive

ii) To apply the sensorless method of MRAS to the system

iii) To do performance comparison/analysis on position control of the system.

1.4 Methodology

Figure 1.1 shows the flow chart of project methodology. It started off with determine the objectives and scope of the project, literature review and to identify the whole system requirement such as device/component, the type of drive system, driver, controller and also the observer. The construction of the open-loop hardware stepper motor system was initiated after procurement of the device has been done. The construction of the circuit is including the controller, driver, interfacing between computer and hardware. And, followed by the developing of the sequences of pulses for stepper motor running in the open-loop system. The signal input or initial position was sent to the driver to rotate the motor shaft to desire position. The feedback from the output signal was then used to compensate the error at the reference input. For the first stage, the encoder will be used to obtain the feedback signal and then will be replaced by observer (MRAS observer) to form a close-loop system. In order to get the MRAS observer, the mathematical modelling and the derivation of the MRAS will be determined. These two experimental will be held to get both result data. The data will be analysed and the performance comparison was carried out between those two conditions.

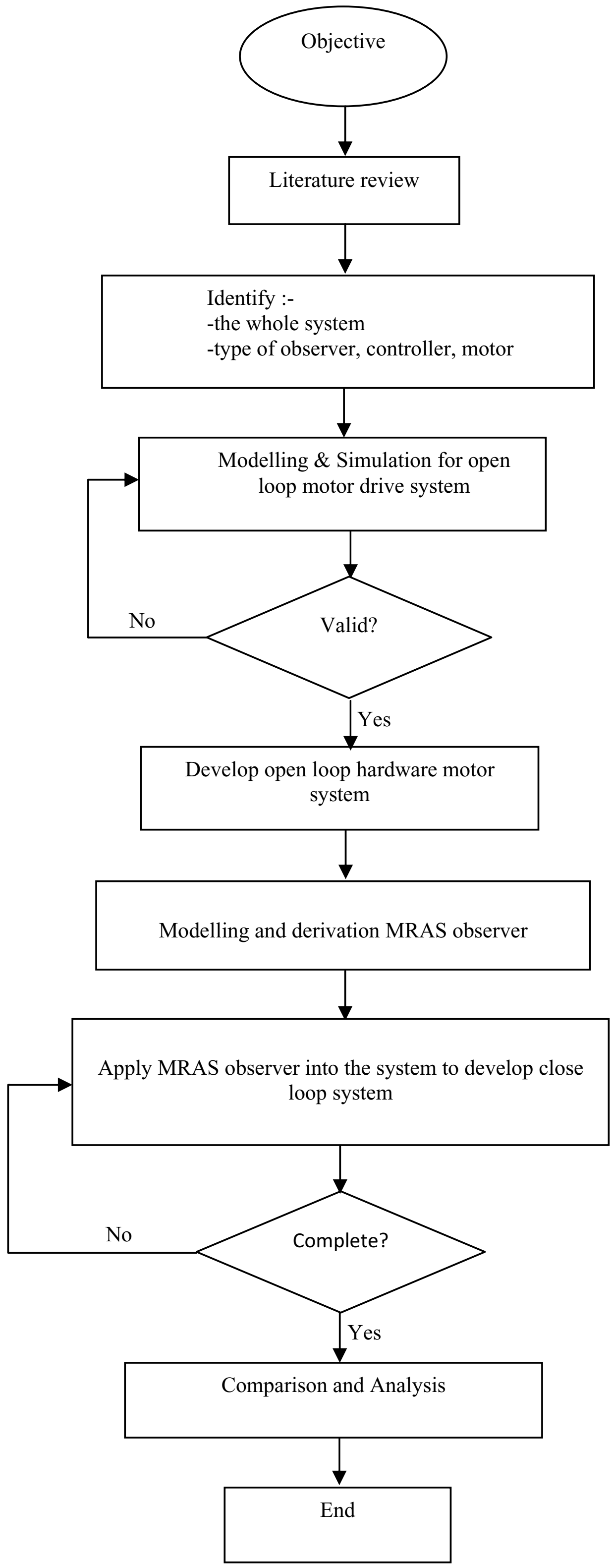

Figure 1.1 Flow Chart Of The Methodology