UNIVERSITI PUTRA MALAYSIA

MULTI-TYPE INTERIOR PERMANENT MAGNET MOTOR DRIVING SYSTEM

SITI KHODIJAH BINTI MAZALAN

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfillment of the Requirements for the Degree of Master of Science

DECEMBER 2011

Dedication

TO MY BELOVED HUSBAND, SONS, FAMILIES AND FRIENDS

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

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Chairman: Assoc. Prof. Norhisam Misron, PhD

Faculty: Engineering

The newly built and specially designed three phase Multi-type Interior Permanent Magnet (MTIPM) motor has led to an invention of the new driving system. The new motor has a special phase independent coil winding and multiple configurations, Permanent Magnet Brushless Direct Current (BLDC) motor and Permanent Magnet Stepper (PMST) motor, which has a specialty in high speed and high torque at low speed function. Therefore, it is potentially suitable for multi-functional and in-wheel motor applications.

Latest trend of conventional motor usually has a single configuration and simplistic driving order that makes none of the existing driving system is suitable for the MTIPM motor. This motor needs a system which can drive multiple configurations and handle the complexity of switching decision and speed control in real time. Thus, a specially designed driving system is essential to drive and control this special motor.

The MTIPM motor driving system is proposed as a new driving and control method for the MTIPM motor. This driving system is capable of driving multiple configurations with a combination of BLDC and PMST motor drivers and a main driving controller. The aims are to achieve smooth switching drive in between the configurations while the motor is running and to provide speed control technique for both configurations.

In this research, combinations of conventional BLDC and PMST motor driver topologies are used to design the MTIPM motor driving system. In addition, National Instrument, (NI) USB-6229 Data Acquisition (DAQ) card is used to act as the main driving controller for the driving system, where it is programmed, monitored and controlled using the NI LabVIEW software in the visual programming language. This programming NI DAQ card controls the selection of drivers, switching interface, motor speed, stops and starts up of the motor by sending a signal to the driving circuit. Constantly, the NI DAQ card requires a continuous feedback signal from the motor to decide on any changes of the motor driving behavior.

Prior to the development of this new driving system, the system is evaluated in several laboratory experiments. The conducted studies in this research show the MTIPM motor behavior while driven by the driving system which is presented in the supply voltage, motor current, motor speed and Hall-effect voltage characteristic, switching state characteristic, speed characteristic, torque versus speed characteristic and load effect characteristic. The results demonstrate the motor real performance and it is elaborated in this thesis. Generally, by the evaluation studies, it is proven in this research that the new invented driving system serves its purpose in

demonstrating a switching drive and control for the special built MTIPM motor. BLDC motor has the advantage in high speed application while the PMST motor has reputation in low speed and positioning application. Hence, with this new driving system, the driven MTIPM motor can combine the advantage of BLDC and PMST motor in one system. To end with, it can be concluded that the objectives stated earlier are successfully achieved with the built of MTIPM motor driving system in this research.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SISTEM PEMACU MOTOR PELBAGAI-JENIS MAGNET KEKAL DALAMAN

Oleh

SITI KHODIJAH BINTI MAZALAN

DISEMBER 2011

Pengerusi: **Prof. Madya Norhisam Misron, PhD**

Fakulti: **Kejuruteraan**

Motor tiga fasa pelbagai-jenis magnet kekal dalaman (MTIPM) yang baru dibina dan direka khas telah menyebabkan sebuah rekaan sistem pemacuan motor yang baru. Motor baru ini mempunyai belitan gelung fasa tersendiri yang khas dan pelbagai konfigurasi, motor magnet kekal arus terus tanpa berus (BLDC) dan motor pelangkah magnet kekal (PMST), yang mempunyai pengkhususan dalam kelajuan yang tinggi dan tork yang tinggi pada kelajuan yang rendah. Oleh itu, ia adalah sesuai untuk pelbagai jenis aplikasi dan motor dalam roda.

Trend terkini motor konvensional biasanya mempunyai konfigurasi yang tunggal dan sistem pemacuan motor yang mudah membuatkan tiada sistem pemacuan motor yang sedia ada sesuai untuk motor MTIPM. Motor ini memerlukan satu sistem yang boleh memacu pelbagai konfigurasi dan menangani kerumitan untuk membuat keputusan penukaran konfigurasi dan kawalan kelajuan pada ketika kejadian. Oleh itu, sistem pemacu yang direka bentuk khas adalah penting untuk memacu dan mengawal motor khas ini.

Sistem pemacu motor MTIPM telah dicadangkan sebagai satu kaedah pemacuan dan kawalan baru untuk motor MTIPM. Sistem pemacu ini mampu memacu pelbagai konfigurasi dengan kombinasi pemacuan motor BLDC dan PMST serta sistem pengawalan pemacuan utama. Ini adalah bertujuan untuk mencapai pemacuan motor yang lancar apabila penukaran di antara konfigurasi ketika motor masih beroperasi dan menyediakan teknik pengawalan kelajuan bagi kedua-dua konfigurasi tersebut.

Dalam kajian ini, kombinasi topologi pemacu motor BLDC dan PMST digunakan untuk mereka-bentuk sistem pemacuan motor MTIPM. Di samping itu, kad Perolehan Data (DAQ) National Instrument (NI) USB-6229 digunakan untuk bertindak sebagai pengawal pemacuan utama untuk sistem pemacu ini, di mana ia diprogramkan, dipantau dan dikawal dengan menggunakan perisian NI LabVIEW yang menggunakan bahasa pengaturcaraan visual. Kad pengaturcaraan NI DAQ ini mengawal pemilihan pemacu, hubung kait penukaran, kelajuan motor, menghentikan dan memulakan motor dengan menghantar isyarat kepada litar pemacu. Kad NI DAQ ini sentiasa memerlukan isyarat maklum balas yang berterusan dari motor untuk membuat keputusan mengenai sebarang perubahan tingkah laku pemacuan motor.

Berikutan pembangunan sistem pemacu baru ini, sistem ini dinilai dalam beberapa uji kaji makmal. Kajian yang dijalankan dalam penyelidikan ini menunjukkan tingkah laku motor MTIPM apabila dikawal oleh sistem pemacuan yang dibentangkan di dalam ciri-ciri voltan masuk, arus motor, kelajuan motor dan voltan kesan-Hall, ciri-ciri status penukaran, ciri-ciri kelajuan, ciri-ciri tork berlawanan dengan kelajuan dan ciri-ciri kesan beban. Hasil keputusan telah menunjukkan prestasi motor yang sebenar dan ia dihuraikan di dalam tesis ini. Secara umumnya,

dengan kajian penilaian ini, penyelidikan ini telah membuktikan prestasi sistem pemacu motor yang baru dicipta ini berkebolehan untuk mendemonstrasikan penukaran pemacuan dan mengawal MTIPM motor yang dibina khas ini. Motor BLDC mempunyai kelebihan dalam aplikasi kelajuan tinggi manakala motor PMST mempunyai reputasi dalam aplikasi kelajuan rendah dan aturcara kedudukan. Oleh itu, dengan sistem pemacu baru ini, motor MTIPM yang dipacu boleh menggabungkan kelebihan motor BLDC dan PMST dalam satu sistem.. Akhir sekali, dapat disimpulkan di sini bahawa objektif-objektif yang dinyatakan sebelum ini telah berjaya dicapai dengan pembinaan system pemacuan motor MTIPM dalam penyelidikan ini.

ACKNOWLEDGEMENTS

All praise be for God, the Almighty and only Creator, with Whose will, blessings and guidance allow the successful accomplishment of this research.

The greatest and sincere gratitude is expressed to my respectful supervisor, Assoc. Prof. Dr. Norhisam Misron for his guidance, valuable advice and kind support throughout the research, all of which have been of great value to this study. I owe my gratitude to my co-supervisor, Prof. Dr. Ishak Aris for his remarkable advice, help and encouragement in completing this thesis.

I am also indebted in so many ways to my husband, Mohd Syahril Noor Shah with whose time, help and support has contributed much to this research. A deepest appreciation also goes to my parents, Mazalan Hussin and Fauziah Zainal and siblings for their support and prayers for the success of this research.

I would like to thank my colleagues Ami Nurul Nazifah, Sharifah Sakinah, Suhairi Rizuan and Raja Nor Firdaus for their kind assistance and warm support. Appreciation also goes to the UPM Faculty of Engineering for providing adequate facilities, likewise to UniMAP and KPT Malaysia for providing financial support with the fellowship program.

Lastly, it is a great pleasure for me to thank all those who had supported me in whatever aspect in the duration of completing this research that made this thesis possible.

I certify that a Thesis Examination Committee has met on 16 December 2011 to conduct the final examination of Siti Khodijah binti Mazalan on her thesis entitled "Multi-Type Interior Permanent Magnet Motor Driving System" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the degree of Master of Science.

Members of the Thesis Examination Committee were as follows:

Suhaidi bin Shafie, PhD
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Zainal Abidin Ab. Kadir, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Chandima Gomes, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Abdul Halim Mohamed Yatim, PhD, Ir
Professor
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Norhisam Misron, PhD Eng.
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Ishak Aris, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____

BUJANG KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

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SITI KHODIJAH BINTI MAZALAN

Date: 16 December 2011

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