IN HUB OF SWITCH RELUCTANCE MOTOR DESIGN FOR ARM JOINT

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)

Faculty of Electrical Engineering

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2013

"I hereby acknowledge that I have read this project report entitle "In Hub Switch Reluctance Motor Design For Arm Joint" and found that it has comply the partial fulfillment for awarding the degree of the Bachelor of Electrical Engineering (Power Electronic and Drive)"

Signature : …….

Supervisor's Name : Dr. Kasrul B. Abdul Karim

Date : …….

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This project report is proposed as to fulfill a fraction
Of the regulations of presentation of the
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2013

”I hereby declare that this report entitle “In Hub of Switch Reluctance Motor Design for Arm Joint”is the result of my own research except as cited in the reference. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree“

Signature	:	……..
Student’s Name	:	Noor Idayu Bt Ahmad
Date	:	……..

Special for my beloved parent

Ahmad bin Saman

Puteh Mahani bt Asha @ Md Isa

Thank you for your continuous support, understanding and advices

My beloved sister

Suraya Ahmad

Suzana Ahmad

Junainah Ahmad

Siti juriah Ahmad

Thank you for your support

For my best friend and others

Nor Mazura Bt Shahrin

Wan Nazlin Bt Wan Abdullah

Nurul Atiqah Bt Ismail

Aisyah Bt Aziz

Nurul Husna Bt Tajudin

Who was always by my side when I need them for support and advices, I really appreciate what they have done. Thanks guys.

Once again, thank you very much and may God bless all of you always.

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ABSTRACT

The main objective of this project is to design a Switch Reluctance Motor (SRM) which is one of the potential actuator for the robotic system. The purpose for this robotic system is generally for arm joint that applicable by the SRM design. The scope is to ensure that the torque will be determined to between 50Nm and 100Nm. Therefore, the project consists of three important parts which is process design, process simulation and analysis. Before start the design process, in hub switch reluctance motor is chose for this application. The SRM design utilizes the parameter that already prescribed in finite element software. This SRM is constructed by placing the pre-calculate value values for the parameters provided in the finite element. After that, process simulation is performed where the motor that design is simulated to get the performance of motor. The performance of switch reluctance motor can be analyzed comprehensively by using finite element. Furthermore the torque and speed can be determined precisely and systematically. In order to archive the high performance of switch reluctance motor, there are several basic parameter has to be identified. Switch reluctance motor need to designed according to basic specification for arm join application. The Finite Element Analysis software were use to design the SRM with suitable profile of the torque, speed, current, voltage and flux linkage.

ABSTRAK

Perkara utama yang dititik beratkan dalam projek ini adalah untuk mereka dan membina "*Switch Reluctance Motor*" di mana ia merupakan salah satu bahagian utama dalam system robotic mesin. Tujuanny aadalah untuk memudahkan sesebuah mesin bergerak dan senang untuk di kawal. Objektifnya adalah untuk memastikan bahawa tork boleh ditentukan kepada antara 50Nm dan 100Nm. Projek ini merangkumi tiga bahagian penting iaitu proses reka bentuk, proses simulasi dan proses analisis. Dalam proses reka bentuk, "Switch Keengganan Motor (SRM)" adalah rekabentuk pilihan yang sesuai untuk bersama lengan. Dalam usaha mereka bentuk, pilihan yang sesuai untuk di hab sendi lengan adalah SRM. Rekaan SRM dasarnya menggunakan parameter yang telah ditetapkan dalam perisian unsure terhingga. SRM ini boleh dibina dengan meletakkan nilai-nilai yang sesuai untuk parameter yang diperuntukkan dalam *Finite Element Analysis*. Setelah SRM direka,proses simulasi adalah proses kedua di mana motor yang telah direka akan di simulasi untuk mendapat prestasi motor tersebut. Prestasi SRM boleh dianalisis secara menyeluruh dengan menggunakan *Finite Element Analysis* Tambahan pula, tork dan kelajuan boleh ditentukan dengan tepat dan sistematik Dalam usaha untuk mencapai prestasi yang tinggi bagi SRM, terdapat parameter asas perlu dikenalpasti. SRM perlu direka bentuk mengikut spesifikasi asas bagi memenuhi kehendak system lengan. Finite Element Analysis telah digunakan untuk merekabentuk SRM yang hadir tork, kelajuan, semasa, hubungan voltan dan berubah-ubah.

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LIST OF ABBREVIATIONS AND SYMBOLS

κ	-	constant
τ	-	torque
Φ	-	flux
I	-	Current
L	-	Inductance
ɵ	-	Position of inductance in degree.
Pout	-	Output power
Pin	-	Input power
ɳ	-	efficiency
CVW	-	Coulomb Virtual Work
MST	-	Maxwell Stress Tensor
N_r	-	Total number pole of rotor
N_s	-	Total number slot of stator
β_s	-	Pole angle of the stator
β_r	-	Pole angle of the rotor
ε	-	permittivity

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Overview

This project is generally about a design of Switch Reluctance Motor (SRM) for arm joint system. The design is for the arm joint system, which SRM has been chosen as the motor that is fit and meet the criteria. The parameters such as torque, relationship flux and current phase indicated in finite element analysis. It is due to that the motor as capable to deliver required torque and can be controlled in an easily. The focus of this study is to developed a simple design of switch reluctance motor that suitable and able meet the characteristic for arm joint application.

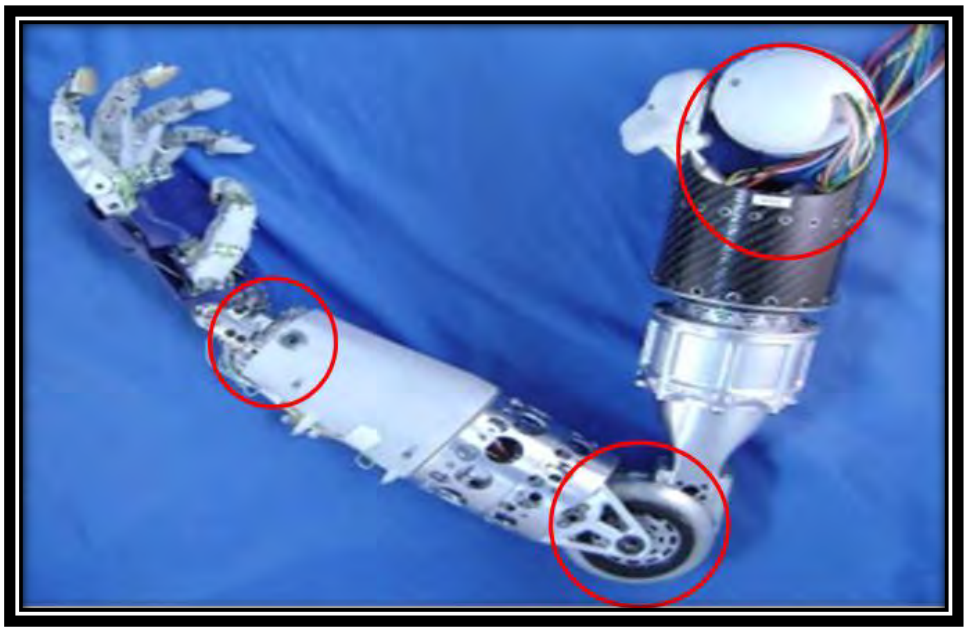

Figure 1.1: Application motor for Robotic Arm System

The main purposed of this project is to design a switch reluctance motor which is one of the potential actuator in the robotic system that shown in Figure 1.1. As the motivation, arm joint is one of the important parts which closely related to an electrical machine application system. SRM has been accredited to offer features that are high efficient, ruggedness, easy manufactured, and cheap. It needs for sensor position and suffer by generating vibration and acoustic noise and high torque ripple are the drawback. In order to meet the specification of the arm joint, efficiency and torque estimate through computation from finite element analysis is a key step in the design process. Corresponding to the purpose the designed switch reluctance motor able to facilitate and produce smooth movement for robot arm joint. The performance of the motors is examined using finite element analysis software.

1.2 Problem Statement

Nowadays, machine usage is very widespread and some critical part of the machine components needs a motor to facilitate movement. In constructing a robot, arm joint is the important areas in movement and one of the components to supplement arm joint perfectly is motor. Commonly, Brushless DC motor is used, however this type of motor is relatively expensive because this motor use permanent magnet and have complex controller.

In order to replace the motor, as other adaptation motor, SRM becomes one of the motor that attractive and have the potential in replacing Brushless DC motor. Switched reluctance motor is suitable and could be an alternative to Brushless DC motor based machines and induction machines in numerous applications. This is because of its structure is simple and rugged construction. In this case, the performance of the switch reluctance motor is required to meet the specification for arm joint by measuring and analyze the torque and efficiency.

1.3 Project Objectives

The major objective of this project is designing a Switched reluctance motor. Its measurable objectives are as follow:

i. To design and develop basic configuration of Switched reluctance motor.
ii. To determine the parameter depend on variable consideration such as length, embrace, yoke thickness and turn per pole.
iii. To analyze the performance characteristics of the switch reluctance motor using finite element analysis (FEA).

1.4 Scope of Project

This project is primarily concerned with the Switched reluctance motor technologies. The scopes of this project are:

i. Analysis the SR Motor using finite element analysis (FEA).
ii. Determine the performance of switch reluctance motor. (100 Nm – 50 Nm and small size).
iii. Analysis the SR Motor structure that consider size, total pole of rotor and total slot of stator.

CHAPTER 2

LITERATURE REVIEW

2.1 Technology Development

In order to design and construct SRM to meet the features that exist on joint arm, extended researches in switch reluctance motor need to be analyze including the basic knowledge of the motor that can be used for the purpose of the project. In addition, background of finite element need to be acquired in order to understand the analysis of switch reluctance motor. The design of Switch reluctance motor of the system will be analyzed due to its performance of torque to select the best possible option.

2.1.1 Switch reluctance motor torque computation from finite element field solution

This project was designed by A. Benhama, A. C. Williamson, and A.B.J. Reece from University of Manchester Institute of Science and Technology (UMIST) (1997). This project discusses basic analysis method switch reluctance motor in order to correct the deficiency and shows that the CVW method can be superior in accuracy and implementation to the MST method [1]. The paper has reviewed existing methods of force and torque computation from the finite element field solutions. It has highlighted the difficulties in the application of the MST method of torque computation to 3D finite element problems, and showed that the CVW method may be superior in accuracy and implementation to the MST method. Application of the CVW method to an experimental switched reluctance motor demonstrated this accuracy. As a result, accounted from CVW 3D stay deep agreement that is very good with data measured, only 4% difference that exists [1]. The FE 3D analysis and method CVW 3D eliminates fully error introduced by effect.

2.1.2 Design and Optimization of High Torque, Low Ripple Switched Reluctance Motor with Flux Barrier for Direct Drive

This project was designed by J. Hur from Korea Electronic Technology Inst , V. Ramanarayanan and B. K. Lee from Changwon National University Power Electronics Group (2005). This project discusses basic analysis the switch reluctance motor by finite element analysis and experimentation and advantages and limitations of using flux barriers in SRM design for high torque. The paper proposes to explore the benefits and limitations of this type SRM and optimize the inserted barriers of rotor in SRM [2].

2.1.3 A Simplified Design Methodology for Switched Reluctance Motor using Analytical and Finite Element Method

This project was designed by M.H.Ravichandran, V.T.Sadasivan Achari, C.C.Joseph and Robert Devasahayam. In This paper gives the step-by-step design procedure of a 16/12 Switched Reluctance Motor for a spacecraft actuator. Machine design has been started with analytical method to fix the major parameters and optimization is carried out using Finite element technique [3]. The Basic design has been started with Analytical method to fix up the major parameters and optimization of dimensions has been carried out using FE method.

2.1.4 Simulation research on Switched Reluctance Motor Modeling and Control Strategy based on ANSOFT

This project was designed by Ling Yuelun, Wang Mianhua,Wang Yan,Wang Fenli from Xi'an University of Science & Technology, Xi'an, Shanxi,. This journal the start methods of the SRM and the optimal angle control, which also provides a theoretical basis for optimization of the SRM structure and parameters, modeling and selection of control method [4].The accuracy and precision of the finite element models were verified by comparing the finite element results with MATLAB simulation results.