FAKULTI KEJURUTERAAN ELEKTRIK

ANALYSIS OF THREE PHASE INVERTER OF BLDC MOTOR

AIN AFIFAH BINTI AHIARUDDIN

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(POWER ELECTRONIC AND DRIVES)

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ANALYSIS OF THREE PHASE INVERTER FOR BRUSHLESS DC(BLDC) MOTOR

AIN AFIFAH BINTI AHIARUDDIN

This Report Is Submitted In Partial Fulfillment of Requirements for the Degree in Electrical Engineering (Power Electronic and Drive)

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DECLARATION

I declare that this thesis entitled "Analysis of Three Phase Inverter for Brushless DC(BLDC) Motor" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : AIN AFIFAH BINTI AHIARUDDIN

Date :

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfillment of Degree of Electrical Engineering (Power Electronic and Drives)

Signature :

Supervisor Name : PUAN NORHAZILINA BT BAHARI

Date :

DEDICATION

To my beloved mother and father

ABSTRACT

This project main purpose to design a three phase inverter of BLDC motor. Brushless DC motor (BLDC) are gaining popularity mainly due to their high efficiency, good dynamic response and very low maintanance. The BLDC motor with trapezoidal waveform of back-EMF have been developed with position sensor which is hall effect sensor. Simulation model of the PI controller for speed control of BLDC motor are also presented. Beside that, conventional PI controller are widely used because of simple structure and easy for implementation. The performance of BLDC motor system is fed by hysteresis current controller with voltage source inverter (VSI). A simulation result analyzed the performance of BLDC motor and compared the performance between PI parameters and speed response in term of overshoot, rise time, and settling time. The modelling, control and simulation of BLDC motor have been done and were carried out by simulated using the MATLAB/Simulink software.

ABSTRAK

Projek Tujuan utama untuk reka bentuk penyongsang tiga fasa BLDC motor. Tanpa berus DC motor (BLDC) semakin popular terutamanya kerana kecekapan yang tinggi, tindak balas dinamik yang baik dan pengurusan penyelengaraan yang sangat rendah. Yang BLDC motor dengan trapezoid bentuk gelombang belakang-EMF telah dibangunkan dengan sensor kedudukan yang sensor kesan dewan. Model simulasi pengawal PI untuk mengawal kelajuan motor BLDC juga turut dipersembahkan. Selain daripada itu, pengawal PI konvensional digunakan secara meluas kerana struktur yang mudah dan mudah untuk dilaksanakan. Prestasi BLDC sistem motor diberi makan oleh histeresis pengawal semasa dengan sumber voltan penyongsang (VSI). Satu hasil simulasi dianalisis prestasi BLDC motor dan dibandingkan prestasi antara parameter PI dan tindak balas kelajuan dalam tempoh terlajak, masa naik, dan masa penetapan. Pemodelan, kawalan dan simulasi BLDC motor telah dilakukan dan telah dijalankan oleh simulasi dengan menggunakan perisian MATLAB / Simulink.

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LIST OF SYMBOLS

BLDC	-	Brushless Direct Current Motor
AC	-	Alternating Current
Back-emf	-	Back Electromagnetic Force
PWM	-	Pulse Width Modulation
VSI	-	Voltage Source Inverter
CSI	-	Current Source Inverter
EMI	-	Electromagnetic
PID	-	Proportional Integral Derivative
Kp	-	Proportional gain
Ki	-	Integral gain

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Due to the their efficiency, silent operation, realibility and compact form, BLDC motor have been desired for small horsepower control motors. Nowadays, household appliance is one of fastest-growing end-product market for electronic motor drive.

Actually, BLDC motor is one type of permanent magnet synchronous motor that can be driven by dc voltage but current commutation is done by solid state switches. The commutation instant are determined by the rotor position that will detected by position sensor or by sensorless technique [1]. These position sensors may be a hall sensors, resolvers or absolute position sensor. The most type of sensor that normally use is hall sensor and optical encoders. These sensor especially hall sensors are temperature sensitive and limit.

Therefore, these sensors could reduce the system reliability because of the components and wiring. Some advantages of BLDC motor compare to brushed DC motor and induction motor is reliable, long operating life, high efficiency and also high dynamic response [2]. Due to an advantages of BLDC motor, this project will focused on BLDC machine with trapezoidal back-EMF and different parameters of speed controller.

This simulation will be model by using MATLAB Simulink Software. Simulation is the most important to evaluate, design and make an analysis of power electronic inverter that apply such as at BLDC motor. The benefit by using MATLAB software because it provides immediate access to thousand of fundamental and can be built-in graphing tools and GUI builder to ensure that can customize data and model to help interpret data more easily for quicker decision making.

Since 1970s PWM technology was already available and broadly apply because it offer many advantages such as to minimize lower order harmonic while the higher order harmonic will be eliminated by using filter. Thus, MATLAB also in affective tool to analyze a PWM inverter. In this project, the choosen switching device use in inverter will be use is switch block because it more easy to control. In order to enhance and improve the performance of electric motor, it can been done by using inverter topologies, control scheme of the electric drive system and also the motor type that have been choosen to fullfil the requirement needed.

1.2 PROJECT MOTIVATION

A brushless DC motor (BLDC) is the most popular of applications for home appliance and industries such as for medical, aerospace and also can be used in outdoor fan in air-conditioner. It is because their advantage that high efficiency, lower weight, reliability and also low cost. To control of BLDC motor, an electronic commutation is applied and will make Power Electronic circuit more complexity. Basically, Voltage Source Inverter (VSI) can be used to achieve accurate and better performance of BLDC motor. Normally, in designing motor drive, the suitable designing is by using modeling and simulation compared to building prototypes because of the cost.

In this project, the simulation of a BLDC motor drive system is developed using MATLAB/Simulink. All realistic components have been included in the simulation circuit. A comparative study for hysteresis and PWM control techniques in controller used to fulfill the requirement during designing the BLDC motor drive. For closed loop operation of the motor drive, a speed controller also has been designed. The modeling of BLDC motor presents a switching technique for sensored BLDC motor with Hall Effect sensor with a setting value of parameters. In the drive block diagram have been designed speed controller for closed loop operation. The design methods of the PI controller also have given.

1.3 PROBLEM STATEMENT

In many cases, the brushless DC (BLDC) motor can replace conventional DC motor. BLDC motor are very suitable for air conditioning system application because of their small size, high reliability, high efficiency and very excellent speed torque characteristics. Induction machines more difficult to control and achieved torque speed range compare to the BLDC motor. In term of efficiency, BLDC motor can operate at unity power factor but for induction machines the best power factor only around 85 percent.

This motor have higher torque ripples compared to the other motor that have a sinusoidal shaped back EMF. They are also cheaper and very suitable to use for general application. The type of switching control of Pulse Width Modulation VSI has used to complete the design. This is because six-step technique inverter normally used widely in the speed of induction motor that can varies the output frequency. So the suitable technique in this project is Hysteresis Current Controller VSI because of their characteristic depends on their excellent dynamic response and easy for implementation. The software will use to analyze this project is MATLAB Simulink. However, MATLAB software will uses a large amount of memory in personal computer (PC) and also make the PC running slowly but it offers high performance numerical computation, data analysis, and application development tools that will help to finished this project.

1.4 OBJECTIVES

The main objective in this project is to design and make an analysis of BLDC motor by using MATLAB Simulink Software. In order to achieve the goal of this project and solve the current problem, an objective of this project is determined:

1) To analyzed the performance of BLDC motor drive.
2) To investigate the performance of BLDC motor in term of trapezoidal drive via Matlab/Simulink simulation.
3) To design the PI controller and analyze the performance of BLDC motor using MATLAB/Simulink

1.5 SCOPE OF RESEARCH

In producing a successful analysis, work, and some project, the scope is required to assist and set the directions of the project development. These scope should be identified and planned appropriately. The main scope is to establish the analysis performance of parameter for BLDC motor with trapezoidal back-EMF and simulate the controller which is PI controller with the modelling of the BLDC motor to compare their performance.

1.6 REPORT OUTLINES

Chapter 1 will fullfill the introduction of three phase inverter for BLDC motor. The overview of project objectives, problem statement for this project analysis, scope of work and methadology project which is the method that uses in order to finish this project.

Chapter 2 focuses on the literature review such as theorytical, basic principles and basic topologies that relates to this project. The research that running is about BLDC motor, inverter and air conditioner.

Chapter 3 discusses about methadology of this project. The gantt chart and flowchart also included in this chapter. This chapter also will discuss about circuit design and the system work. Other than that, in this chapter will discuss about related previous work and will make a comparison about this.

Chapter 4 will explain the results obtain during construction circuit in Matlab Simulation. Among the result that will be discussed about output waveform which is sinusoidal and trapeizoidal waveform that will produce in different input voltage.

Chapter 5 will discuss about the conclusion and the advantages of the method had been implemented into this project. This chapter also gives the recommendation to improve software or anything else related to the project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF DC MOTOR

In daily life, an electric equipment that we use often to have at least one motor used to rotate an object from its position. In the market have many type of motor such as induction motor, servomotors, DC motor (brushed and brushless). To choose the suitable type of motor depends on the application requirement [3].

2.1.1 Construction

Figure 2.1 shows the dc motor that have an armature on the rotor. The stator has salient magnetic poles that are either made of permanent magnets or special field windings. Current is fed to the rotor windings through brushes that are in contact with commutator segment lcated at the end of the rotor. For more understanding, commutator segments also can be known as copper strips which are connected to the rotor windings [4].

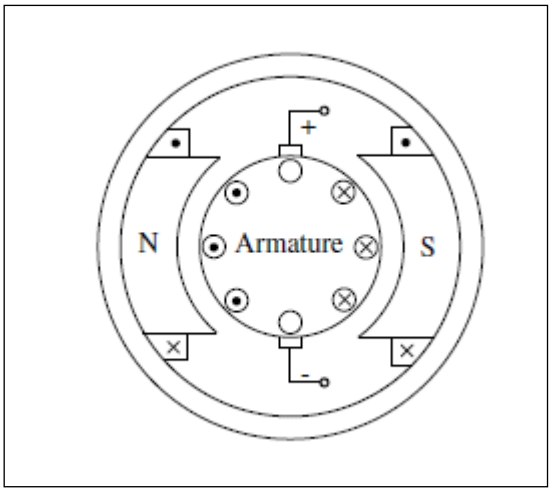

Figure 2.1: Cross section of a two pole dc motor

As the rotor states, the brushes move from one segment to another which commutates the current in such a way that the currents in the conductor under each pole flow in the same direction which is from stator point of view have been depicted in Figure 2.2. The resulting force vectors that act on the rotor windings are all tangetial to the rotor periphery and contribute to the torque.

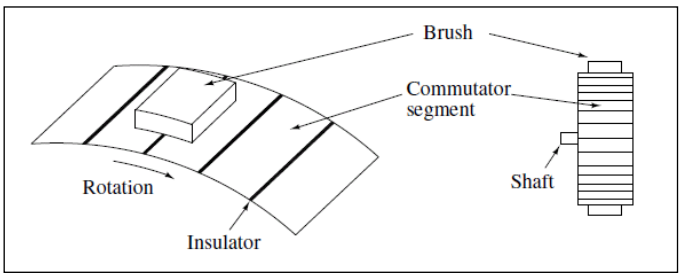

Figure 2.2: Brush and commutator segment of dc motor

2.2 BRUSHLESS DC (BLDC) MOTOR

2.2.1 Introduction

Brushless DC motors also can be known as electronically commutated motors that are powered by direct-current (DC) electricity and having electronic commutation systems rather than mechanical commutator and brushes [5]. BLDC motor having permanent magnets on the rotor and trapeizoidal shape back-EMF. BLDC motor also one kind of permanent magnet synchrous motor. The Brushless Direct Current (BLDC) motor used in a medical application, industries and also used in aerospace and defense application for recent years. It very ideal for application that require high reliability, high efficiency and high performance motor because it capable to providing large amount of torque over a vast speed range.

The application that suitable for BLDC motor such single-speed applications, adjustable speed, position control, and in low-noise application. In term of single speed, BLDC are good for this application because of the flat speed torque curve when speed has to be maintained in the variation of load. To monitor torque, speed and position control for BLDC motors a complex controllers and optical encoder can use for it. The BLDC motors also generate EMI and noise but its better compare to Brushed DC motor [2].

Other than that, the household appliance such as room conditioner, refrigerator, water heaters and medical application also use BLDC motor for example of medical application such as Sleep Apnea Treatment because the higher heat will transfer efficient to allow them to run cooler in crowded spaces.