ANALYSIS OF TOTAL HARMONIC DISTORTION FOR H-BRIDGE INVERTER IN DC MOTOR APPLICATION

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2021

DECLARATION

I declare that this thesis entitled "ANALYSIS OF TOTAL HARMONIC DISTORTION FOR H-BRIDGE INVERTER IN DC MOTOR APPLICATION" 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 : 

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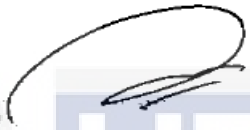
Date : 2 July 2021

APPROVAL

I hereby declare that I have checked this report entitled "ANALYSIS OF TOTAL HARMONIC DISTORTION FOR H-BRIDGE INVERTER IN DC MOTOR APPLICATION" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : 

Name : Siti Azura Binti Ahmad Tarusan

Date : 4 July 2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

DC motor that conducted in the four-directional operation (forward and reverse) is implemented in the wide variety of different devices and appliances of industrial machines. H-bridge or full-bridge circuit is the appropriate circuit to allow the operation of DC motor. However, DC motor represented by using resistive-inductive load (RL load) may produce a harmonic distortion problem. The harmonic can cause an energy loss and increasing heat that may deteriorate the insulation as well as decrease the efficiency of motor. Due to this, this thesis will issue the high total harmonic distortion (THD) if the improper switching is used. The RL load will perform the square waveform and sinusoidal waveform. The sinusoidal waveform can be performed by using bipolar and unipolar switching scheme. In term of current performances, the output generated in sinusoidal waveform will produce the low THD compared to the square waveform. Apart from that, the performance of the inverter depends on the control strategy adopted to generate the gate pulses. Therefore, the current control methods are used to control the inverter. This thesis presents model of proposed hysteresis current controller (HCC) for h-bridge inverter to improve the total harmonic distortion by using hysteresis current controlling method. The proposed HCC is capable for lowering the THD and to provide constant switching frequency. The step development of the analysis of total harmonic distortion for h-bridge inverter will be discussed. It focuses the PWM definition and consideration in terms of frequency modulation index and amplitude modulation index. To validate the results, MATLAB/Simulink software will be implemented. The current waveform and total harmonics distortion will be applied to analyse the performance of h-bridge inverter.

ABSTRAK

Motor DC yang dijalankan dalam operasi empat arah (maju dan mundur) dilaksanakan dalam pelbagai jenis alat dan peralatan mesin industri. Litar H-bridge atau full-bridge adalah litar yang sesuai untuk membolehkan operasi motor DC. Walau bagaimanapun, motor DC yang diwakili dengan menggunakan beban resistif-induktif (beban RL) boleh menghasilkan masalah penyelewengan harmonik. Harmonik boleh menyebabkan kehilangan tenaga dan peningkatan haba yang boleh merosot penebat serta mengurangkan kecekapan motor. Oleh kerana itu, tesis ini akan mengeluarkan distorsi harmonik total (THD) yang tinggi sekiranya peralihan yang tidak betul digunakan. Beban RL akan melakukan bentuk gelombang persegi dan bentuk gelombang sinusoidal. Bentuk gelombang sinusoidal dapat dilakukan dengan menggunakan skema pensuisan bipolar dan unipolar. Dari segi prestasi semasa, output yang dihasilkan dalam bentuk gelombang sinusoidal akan menghasilkan THD yang rendah berbanding dengan bentuk gelombang persegi. Selain itu, prestasi penyongsang bergantung pada strategi kawalan yang digunakan untuk menghasilkan denyut gerbang. Oleh itu, kaedah kawalan semasa digunakan untuk mengawal penyongsang. Tesis ini menyajikan model pengawal arus histeresis yang dicadangkan (HCC) untuk penyongsang h-bridge untuk memperbaiki keseluruhan penyimpangan harmonik dengan menggunakan kaedah pengendalian arus histeresis. HCC yang dicadangkan mampu menurunkan THD dan memberikan frekuensi beralih berterusan. Langkah pengembangan analisis keseluruhan distorsi harmonik untuk penyongsang h-bridge akan dibincangkan. Ia memfokuskan definisi dan pertimbangan PWM dari segi indeks modulasi frekuensi dan indeks modulasi amplitud. Untuk mengesahkan hasilnya, perisian MATLAB / Simulink akan dilaksanakan. Bentuk gelombang semasa dan penyimpangan harmonik total akan digunakan untuk menganalisis prestasi penyongsang h-bridge.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

DC	-	Direct Current
AC	-	Alternating Current
THD	-	Total Harmonic Distortion
EMF	-	Electromotive Force
HCC	-	Hysteresis Current Control
R	-	Resistance
L	-	Inductance
m_a	-	Amplitude Modulation Index
m_f	-	Frequency Modulation Index
UPS	-	Uninterruptible Power Supplies

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

DC motor are becoming popular nowadays due to its advantages that are higher starting torque, faster starting and stopping, reversing, variables speed with voltage input, easy to maintenance and cheaper to control than AC motor. There are many papers which detail the principle and modelling of DC motor applications. Therefore, this thesis presents the analysis of h-bridge inverter for DC motor applications in term of current and THD performance. Basically, h-bridge inverter is used due to being uncomplicated in controling the direction of DC motor and most motors need extra power supply than any microcontroller because of h-bridge uses outer power source. However, the performance of inverter relies upon at the control method adopted to generate gate pulses. In other term, the gating signal is a digital signal or pulse that determines a time window so that pulse from among many will be choosen and others will be block or eliminated. Normally, to control inverter, it uses the current control method. There are various current control methods, hysteresis controller is the most famous one, with suitable balance speedy reponse, peak current control capability and smooth to design. The analysis of total harmonic distortion for h-bridge inverter in terms of varies of frequency modulation index and amplitude modulation index is implement with the variations of proposed hysteresis current controller inverter. In this paper, performance of total harmonic distortion for h-bridge inverter are analysed and compares in MATLAB/Simulink environment.

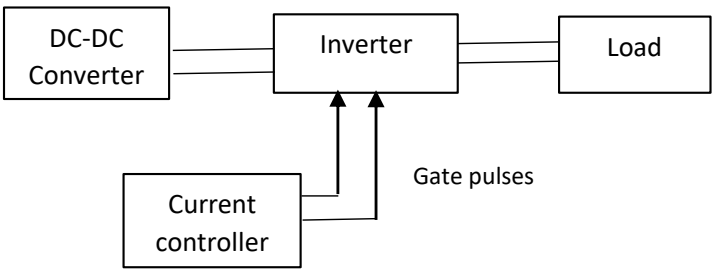

Figure 1 Block diagram of h-bridge inverter

1.2 Motivation

In nowadays's life which is full with innovation, DC motor drives is having the glory of demanded by worldwide sector of industrial particularly sustainable energy technology, the solar power has a few favorable circumstances like, power, limitless, and gives sustainable electricity. In any case, the solar electricity can provide the dc energy, and thus he conversion of DC to AC power requires power electronics and control gears. In dissimilar utilization, the purpose is when the DC voltage source can be reached, it can make the AC voltage. An inverter capable of making an ac output derived from the type of dc input it highly emphasizes. In operations of using inverters, for example, uninterrupted power supplies (UPS), movable-speed ac motor drives, and running ac apparatuses from an automobile battery. They are acquiring a great deal of consideration by the industrial sector and domestic sector because of their performance and commitment to the areas. An H-bridge is a computerized variety of circuit that empowers a voltage enforced over a load or both directions in either simplest approach to control DC motor heading. Other than that, comparative analysis between control methods of inverter is additionally introduced and discussed.

1.3 Problem Statement

DC motor that four-directional operation (forward and reverse) widely used in the application of industrial machines. However, the forward and reverse dc motor requires the suitable circuit to apply both applications. Thus, h-bridge or full-bridge circuit is suggested to allow the operation of forward and reverse motor. In general, full bridge will produce two types of output voltages: 1) square waveform, and 2) sinusoidal waveform. In term current performances, the output generated in sinusoidal waveform will produce the low THD current compared to the square waveform. Furthermore, the sinusoidal waveform can be performed by using bipolar and unipolar switching scheme. DC motor that is represented by using resistive-inductive load (RL load) may produce a harmonic distortion problem. The harmonic can cause an energy loss and increasing heat that may deteriorate the insulation as well as decrease the efficiency of motor. Thus, the RL load will produce the high total harmonic distortion (THD) current if the improper switching is used. In addition, the improvement of THD for h-bridge inverter is evaluated by using current control methods, to obtain the better level of reducing total harmonic distortion it may be used as the gate signal in h-bridge inverter. Therefore, the investigation of h-bridge inverter circuit will be conducted to analyse the performance of total harmonics distortion in the variation of frequency and amplitude modulation index.

1.4 Project Objective

1. To study the principle operation of h-bridge inverter for DC motor applications.
2. To design and simulate the h-bridge inverter circuit by using unipolar and bipolar switching in MATLAB/Simulink software.
3. To design and simulate the h-bridge inverter circuit by using hysteresis current controller in MATLAB/Simulink software.
4. To analyse and compare the total harmonic distortion performance of h-bridge inverter circuit.

1.5 Project Scopes

This kind of project will be consisting of only the one crucial part which will be the simulation part. The scope of project included are study and understand the principle operation of h-bridge inverter for DC motor applications. By using MATLAB/Simulink software to simulate full-bridge circuit; 1) square waveform and 2) sinusoidal waveform by using unipolar and bipolar switching scheme. Apart from that, the current control methods are used to generate the gating signal by using hysteresis current controller to maintain low THD level. Besides, we also enhance knowledge on the application of MATLAB/Simulink software which is taking part in this project implementation. Other than that, by using FFT Anlaysis tools to illustrate the desired output waveform by using the MATLAB/Simulink software and develop the project to counter the performances of total harmonic distortion for h-bridge inverter and analyse the current performances when varies frequency modulation index and amplitude modulation index.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section, various research related to the hysteresis current control for DC motor and inverter was identified and summarized which will obviously expands our knowledge regarding the method operation of the hysteresis current controller, characteristics of hysteresis current controller and method of inverter, the performance in term of total harmonic distortion that will affect the system that used for the gating signal control. Every each of the research will be analysed and explained briefly to expose more about the research that have been done by the past researchers.

This area will be discussed about the past related work such as theory, analysis, synthesis, and evaluation of project. All the works have been summarized and briefly explained based on the hysteresis control for and other factors that were seems to be related to this project.

2.2 DC Motor Fundamentals

A DC motor is an electric type of motor that sudden increment in DC power request. The operation is dependent on the straightforward of electromagnetism in an electric motor. A current-conveying conductor will generate a field of magnetic, when the positioned in an outer magnetic field, it will encounter or experience a power that is corresponding on the conductor current and to the outer magnetic field strength. It is an equipment which transforms electrical power into mechanical power. It removes at the route that a current-conveying conductor place in a field of magnetic occurrence a power will make it pivot regarding its initial position [1].

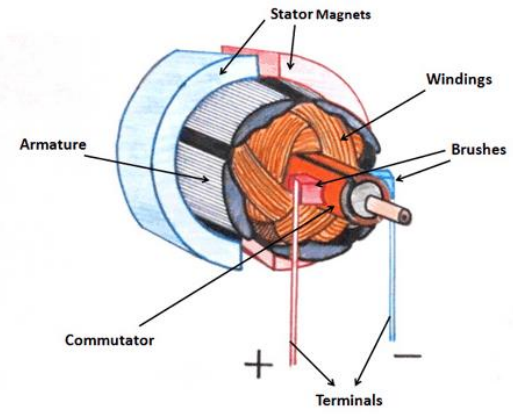

Figure 2 Example of DC motor basic part

2.2.1 DC Motor Constructions

Figure below shows the constructions of DC motor.

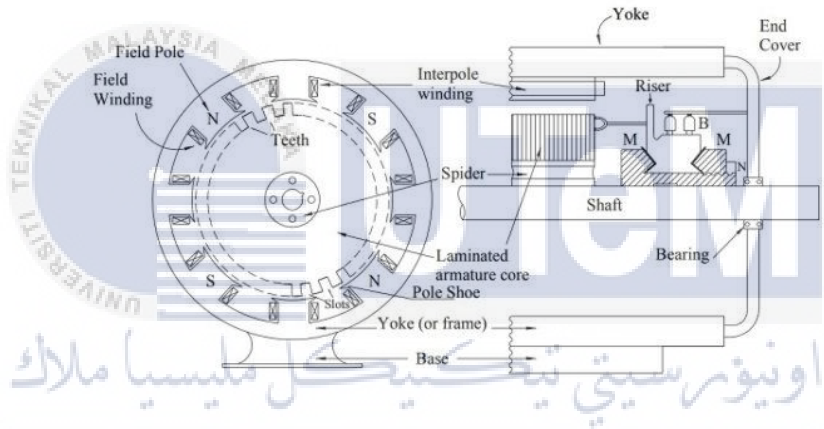

Figure 3 Example of DC motor constructions

The construction generally consists of:

Parts of DC motor	Explanation
Yoke	The yoke of DC motor content of steel or magnetic casing either cast iron and structures a basic piece of the stator or the motor static piece.
Field pole	Inside the yoke there are mounted of field shafts that made of slight overlay stacked together, it composes of pole cores and pole shoes.
Field winding	Field winding are built with copper wire (field coils) turned over the openings of the pole shoes in such single way that when courses of current field via it.

Armature	Armature winding- joined to the rotor, or the machine turning part, and subsequently is bare to changing magnetic field in the way of the rotary which directly to the losses of magnetic.
Commutator	Current transfer from the principal to the armature winding housed over a pivoting structure to encourage the assortment of current from armature by involve DC motor with relay.
Brushes	The armature winding streams to turning commuter structure that used by relay the current from outside. The DC motor brushes are made with the graphite structures carbon, pivoting commutator that connect.
Slot/Teeth	For mechanical assist, ensure from corrosion, and electrical insulation, non-conducting slot liners are commonly wedged to the loops and the space dividers and teeth is the magnetic material between the opening.

2.2.2 Principal Operation of DC motor

DC motor known as an equipment that changes the dc power to mechanical energy. When the current conveying conductor is put in a magnetic field, the conductor encounters a withstands the mechanical force and the work of the DC motor depends on this rule. The force movement direction is Fleming's left hand rule [2].

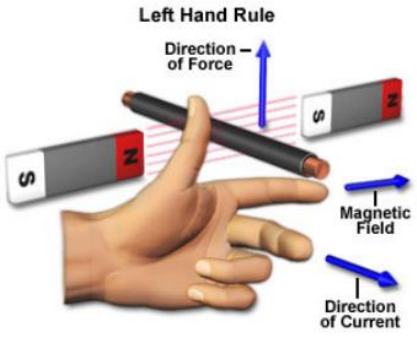

Figure 4 Fleming Left Hand Rule

Fleming's left-hand rule (force movement direction) and its magnitude is given by:

$$\boldsymbol{F = ILB} \qquad (2-1)$$

where I is current, B is magnetic flux density while L is the length of the conductor within the magnetic field.

When off chance that the thumb, by a point 90° of the forefinger (left hand) and middle finger are uprooted from one another while the bearing of the magnetic field speaks the middle finger. The pointer speaks to the route of the current and shows the thumbs of the direction of forces by follow up on conductor [1][2].

Operation of DC motor

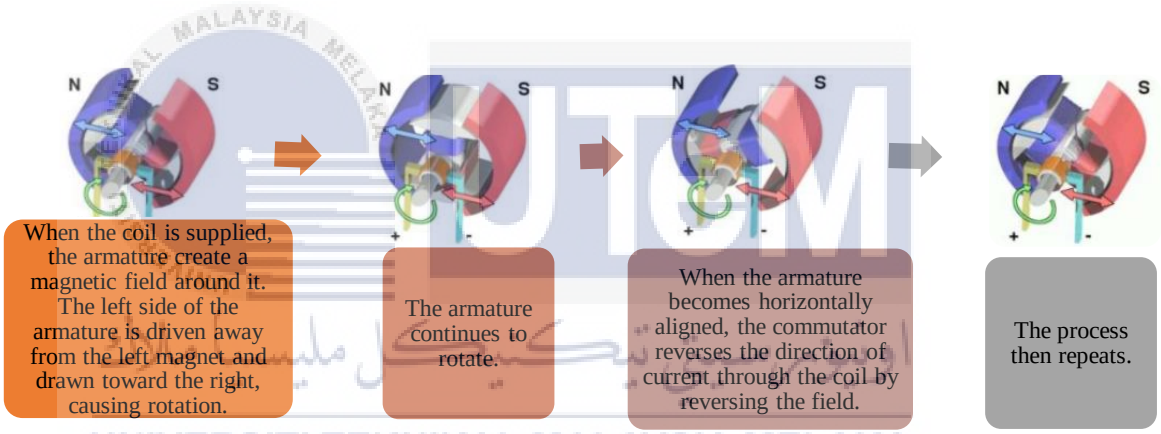

Figure 5 Working operation of DC motor.

Therefore, the rear emf in a DC motor do regulate the armature current flow, it automatically alters the armature current to fulfil the load requirement [1].

2.2.3 Application of DC motor

Based on figure below, the main applications of the direct current motors divided with three types which are,

Series Motor

- To provide higher starting torque when varies in speed is required by using this series DC motor.
- Industrial application –system traction, sewing machines, cranes, vaccum cleaner and compressors in air.

Shunt Motor

- To gives constant of speed and starting conditions (not severe).
- Industrial application -Lathe machines,lifts, pumps in centrifugal, conveyors, machine of weaving, spinning machines and blowers.

Compound Motor

- Provide higher starting torque and fairly constant speed are possible.
- Industrial application -Presses, heavy planners, elevators, rolling mills, conveyors and shears.

Figure 6 Example of series, shunt, and compound motors