NEAR TO DC LEVEL MULTILEVEL INVERTER

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DEDICATION

This project is dedicated to my Late beloved son Muhammad Umer who died during my masters and my wife who was shaken with a lot of sacrifices she made because of me. My Father who himself is an electrical engineer, guided me throughout my journey of engineering. I saw my father work hard in his field and made me curious to look forward on his steps. I also dedicate my work to my mother who taught me the manners and norms of my life, she is a working lady along with my father worked so hard to feed me and my siblings. My mentor Sir Dr. Touqeer Jumani has a big role in my UTM life as well. He was the one who made my life easier in UTM and guided and helped me whenever I needed him. I feel necessary to mention my ideal teacher who passed away during my masters Late Prof. Azhar Khairuddin..

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ABSTRACT

The purpose of this study is to investigate the application of genetic algorithm (GA) in modelling linear and non-linear dynamic systems and develop an alternative model structure selection algorithm based on GA. Orthogonal least square (OLS), a gradient descent method was used as the benchmark for the proposed algorithm. A model structure selection based on modified genetic algorithm (MGA) has been proposed in this study to reduce problems of premature convergence in simple GA (SGA). The effect of different combinations of MGA operators on the performance of the developed model was studied and the effectiveness and shortcomings of MGA were highlighted. Results were compared between SGA, MGA and benchmark OLS method. It was discovered that with similar number of dynamic terms, in most cases, MGA performs better than SGA in terms of exploring potential solution and outperformed the OLS algorithm in terms of selected number of terms and predictive accuracy. In addition, the use of local search with MGA for fine-tuning the algorithm was also proposed and investigated, named as memetic algorithm (MA). Simulation results demonstrated that in most cases, MA is able to produce an adequate and parsimonious model that can satisfy the model validation tests with significant advantages over OLS, SGA and MGA methods. Furthermore, the case studies on identification of multivariable systems based on real experiment t al data from two systems namely a turbo alternator and a continuous stirred tank reactor showed that the proposed algorithm could be used as an alternative to adequately identify adequate and parsimonious models for those systems. Abstract must be bilingual. For a thesis written in Bahasa Melayu, the abstract must first be written in Bahasa Melayu and followed by the English translation. If the thesis is written in English, the abstract must be written in English and followed by the translation in Bahasa Melayu. The abstract should be brief, written in one paragraph and not exceed one (1) page. An abstract is different from synopsis or summary of a thesis. It should states the field of study, problem definition, methodology adopted, research process, results obtained and conclusion of the research. The abstract can be written using single or one and a half spacing. Example can be seen in Appendix 1 (Bahasa Melayu) and Appendix J (English).

ABSTRAK

Kajian ini dilakukan bertujuan mengkaji penggunaan algoritma genetik (GA) dalam pemodelan sistem dinamik linear dan tak linear dan membangunkan kaedah alternatif bagi pcmilihan struktur model menggunakan GA. Algorithma kuasa dua terkecil ortogon (OLS), satu kaedah penurunan kecerunan digunakan sebagai bandingan bagi kaedah yang dicadangkan. Pcmilihan struktur model mengunakan kaedah algoritma genetik yang diubahsuai (MGA) dicadangkan dalam kajian ini bagi mengurangkan masalah konvergens pramatang dalam algoritma genetik mudah (SGA). Kesan penggunaan gabungan operator MGA yang berbeza ke atas prestasi model yang terbentuk dikaji dan keberkesanan serta kekurangan MGA diu t arakan. Kajian simulasi dilakukan untuk membanding SGA, MGA dan OLS. Dengan meggunakan bilangan parametcr dinamik yang setara kajian ini mendapati, dalam kebanyakan kes, prestasi MGA adalah lebih baik daripada SGA dalam mencari penyelesaian yang berpotensi dan lebih berkebolehan daripada OLS dalam menentukan bilangan sebutan yang dipilih dan ketcpatan ramalan. Di samping itu, penggunaan carian tcmpatan dalam MGA untuk menambah baik algorithma tersebut dicadang dan dikaji, dinamai sebagai algoritma mcmetic (MA). Hasil simulasi menunjukkan, dalam kebanyakan kes, MA berkeupayaan menghasilkan model yang bersesuaian dan parsimoni dan mcmenuhi ujian pengsahihan model di samping mcmperolehi beberapa kelebihan dibandingkan dengan kaedah OLS, SGA dan MGA. Tambahan pula, kajian kes untuk sistcm berbilang pcmbolehubah menggunakan data eksperimental sebenar daripada dua sistem iaitu sistem pengulang-alik turbo dan reaktor teraduk berterusan menunjukkan algoritma ini boleh digunakan sebagai alternatif untuk mcmperolehi model termudah yang memadai bagi sistcm tersebut.

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LIST OF ABBREVIATIONS

MLI	-	Multi-Level Inverter
CSI	-	Current Source Inverters
VSC	-	Voltage Source Inverters
FC	-	Flying Capacitor
NPC	-	Neutral Point Clamped
CHB	-	Cascaded H-Bridge
PWM	-	Pulse Width Modulation
PD	-	Pulse Disposition
POD	-	Pulse Opposition Disposition
NLC	-	Nearest Level Control
NLM		Nearest level Modulation
% THD		Total Harmonic Distortion percentage
UTM		Universiti Teknologi Malaysia

CHAPTER 1

INTRODUCTION

1.1 Background

In the new era of technology, inverters have gained enormous importance. Nowadays, everything is converting from manual to digital and mechanical to electrical because digitalization depends on electrification. Previously the time was leaning towards mechanical industries. The dominance of mechanics was at most; however, nowadays, the time has changed, and everything is preferred to be comfortable, adaptable, and more reliable. Industries have converted themselves to robotics rather than human labor, which increases the industry's output and, hence revenue. Apart from that, all these industries use colossal energy for productivity and utilities, so more energy is demanded. The government sectors of energy and independent private plants for electricity manufacturing are looking for ways to ease, soothe and advance electricity generation. Various ways can achieve that. It can be by converting natural resources of energy into electricity through various processing units or using fossil fuels to extract energy to generate electricity.

However, there are two different types of electric currents produced in generating units, i.e., in industry, AC and DC electricity types are most needed, but both have their areas to cover for the preferred use. Somewhere in the transmission of electricity in long lines to lessen the losses and cut the cost of transmission, DC voltage is used. In contrast, commercially or domestically, AC voltage is mostly used in single or three phases forms.

As we speak about converting one form of voltage to another form, electronics' functions emerge. We have to convert AC type of voltages into DC type known as Rectification, whereas converting DC to AC is known as Inversion, so the devices are called Rectifiers and Inverters. Some energy resources generate electricity in DC voltage type, which is indeed undesired when used for domestic or most industrial purposes, so, for that reason, inverters play an essential role in converting from DC to AC. Now it is a vast field of conversion. There are many aspects in the design, implementation, simulation, and economy of the inverters' components for said purpose.

Two types of inverters are Current Source Inverters (CSI) and Voltage Source Inverters (VLI) [1]. VLI being the widely used inverter classified into a 2-level inverter and Multilevel inverter MLI [2]. MLIs are mostly the same as 2-level inverters, but the difference is these can handle a vast amount of powers. They are the ones mostly used many applications, mostly in renewable energy technologies [3-5], high voltage DC (HVDC) [6,7], motors and drives [8,9], active-power filters [10], Electric vehicles (EV) [6,7], microgrids [11], distributive static compensators (DSTATCOM) [12] and flexible AC transmission devices (FACTS) [13,14].

These are the combination of more inverters half (one leg) or full (2 legs); hence, these numbers are called inverter levels. Each level involves no. of semiconductor devices also called switches like IGBT, MOSFET, FET etc. These devices' primary function is switching on and off, making a path for current or vice versa. Figure 1.1 shows different outputs of using variable no. of switches being used in a circuit.

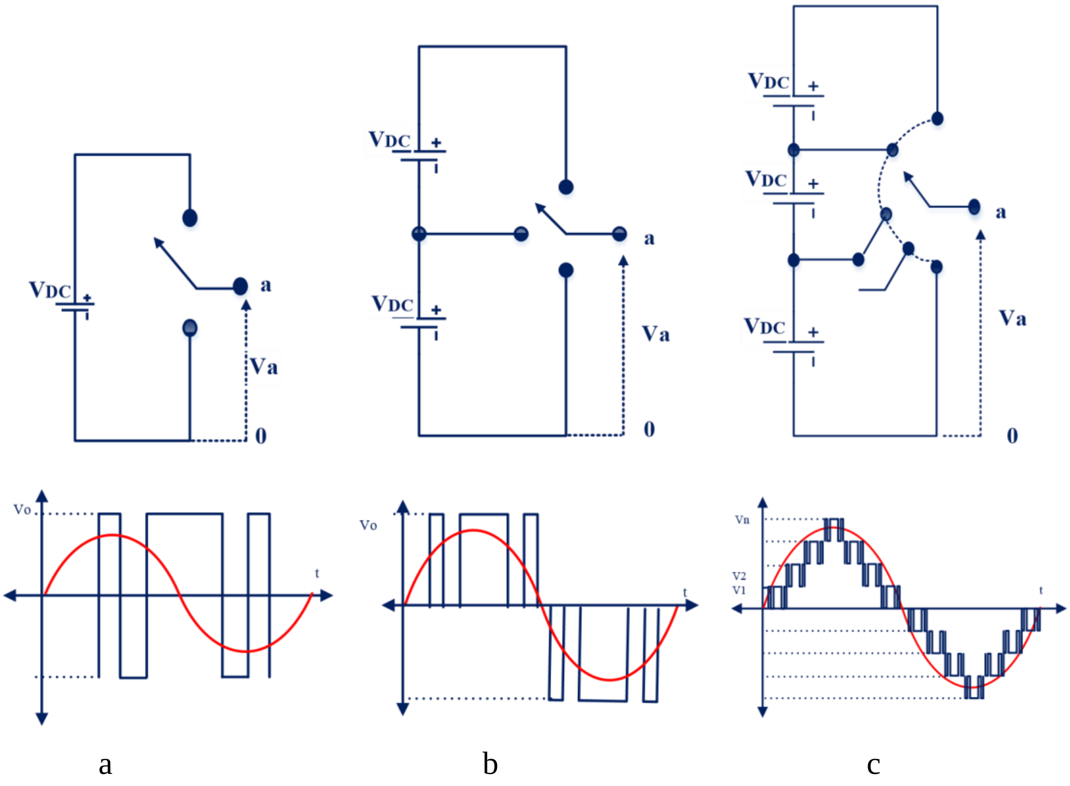

Figure 1.1 Examples of (a) 2-level inverter (b) 3-level inverter (c) n-level inverter

1.2 Problem statement

There is a concern about proper energy utilization in this modern era of technology, which means getting more out of some. Since we know all the electrical equipment have an area of losses, which is a constant issue to be used as research work. Not to increase the energy loss but to save energy and make the system efficient by utilizing most of the energy in the bunch of electrical equipment. Inverters also deal with handling power since MLI has the upper hand on a typical inverter to handle a considerable power within its system. So the concern of this project is similar in that It is to minimize the level of 'Total Harmonic Distortion (THD)' of AC signal output while designing the MLI using the Nearest level Control Modulation(NLC) technique. The concern of this project is to design, simulate and discuss the performance of the circuit topology of 7, 9 and11-level Cascaded H-Bridge MLI using level shift Pulse width modulation's types are Pulse Disposition (PD), Pulse Opposition Disposition(POD), and Alternative Pulse Opposition disposition (APOD), also to simulate the same circuit with Nearest level control modulation technique(NLC). It then analyzes and discusses their performance in regards to the voltage %THD profile of the output. Further, to analyze any way to create a better version of NLC that can provide a better %THD profile.

1.3 Objectives

i. To design and simulate a 7,9, and 11-level CHB-MLI using PD-PWM, POD-PWM, APOD-PWM. Also, to design and simulate the same topology of 7,9 and11-level CHB-MLI circuit using NLC modulation technique.
ii. To analyze and discuss the performance of the techniques in use.
iii. To analyze and discuss the voltage %THD profile of said MLI circuits.
iv. To achieve the most efficient output while using the NLC technique with some modification.

1.4 Scope of research

This project's work is based on design, simulation, analysis, and discussion of different MLI versions using conventional PD-PWM, POD-PWM and APOD-PWM techniques, along with that NLC modulation techniques are also used. The model would be using 7, 9 and 11–level cascaded H-bridge type MLI for this project. Three, four and five symmetrical DC voltage sources of 100V for 7, 9 and 11 levels MLIs respectively are used as a fundamental input for the cascaded blocks. Hence each module contributes 100V and for 7-level, 9-level and 11-level MLI the voltage is set to 300V, 400V, and 500V. Switching frequency is set to 1kHz. The modulation index is set to 1 for PWM.

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