FUZZY SLIDING MODE CONTROLLER FOR CASCADED MULTILEVEL INVERTER

ALSHAMMARI FAHAD SHUMRAN

UNIVERSITI TEKNOLOGI MALAYSIA

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ALSHAMMARI FAHAD SHUMRAN

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This thesis is dedicated to my father

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ABSTRACT

This research provide an analytical study to sliding mode controller and fuzzy sliding mode controller for cascaded 5-Level inverter. The cascaded 5-Level inverter used in this research is implemented based on phase shifted Pulse width modulation technique. An output LC filter is used to reduce harmonics elements. The system is implemented mathematically using a state space representation. Then the averaging model is obtained on order to prepare the system's equations to be appreciated with sliding mode method. After modeling the system, sliding mode controller is designed. Lastly, Fuzzy logic controller is designed with desired scaling factor to fuzzify the sliding surface. Both controller are connected to three types of load to identify their behavior. The simulation results show that the proposed fuzzy sliding mode controller is more robust than sliding mode controller.

ABSTRAK

Penyelidikan ini menghasilkan jajian analitikal alat kawalan mod sliding dan mod fuzzy sliding kepada 5 tahap jujukan alat penyonsang. Alat kawalan 5 tahap jujukan alat penyongsang yang digunapakai di dalam kajian ini adalah berdasarkan teknik modular pertukaran lebar denyutan. Oleh itu, penapis LC digunakan untuk menurunkan elemen harmoni. Secara matematiknya, sistem ini dilaksanakan secara’a state space representation. Kemudian model pemurataan diperolehi untuk menyediakan persamaan sistem untuk kaedah mod sliding. Kemudian model ini direkabentuk. Akhir sekali, alat kawalan fuzzy direkabentuk berdasarkan pengukuran yang diperlukan untuk fuzzify permukaan sliding.

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LIST OF ABBREVIATIONS

PV	-	Photovoltaic
UPS	-	uninterruptable power supply
FLC	-	Fuzzy Logic Controller
SMC	-	Sliding Mode Controller
FSMC	-	Fuzzy Sliding Mode Controller
THD	-	Total Harmonic Distortion
PWM	-	Pulse Width Modulation
STATCOM	-	static synchronous compensator
FFT	-	Fast Fourier transform
FWR	-	Full Wave Rectifier

CHAPTER 1

INTRODUCTION

1.1 Background

Recently, the demand of energy conversion through power electronics are extremely increased. This because their capability and precise conversion of voltage, current, and frequency. The inverters is the most essential component of any DC to AC conversion equipment such as Photovoltaic (PV) inverters, induction motor drive, or the uninterruptable power supply (UPS), etc. The Inverter's main function is to transfer power from DC source into AC load. The process of conversion is achieved by using switches that are switched independently according to appreciate switching mechanism. Many topologies are offered in order to provide such process. Multilevel inverter is a common topology of inverters introduced by [1] [2]. The idea of multilevel inverter is to generate sinusoidal voltage by several levels of voltages. The advantages of using multilevel converter are to achieve a higher voltage capability, reduce the content of harmonics, reduce the EMI, and reduction of switching losses [3].

In some applications,cascaded multilevel inverter is required to provide a pure and stable sinusoidal AC voltage regardless of the type of load that is connected to it. It also requires being capable to recover from transients caused by external disturbances as quickly as possible. However, the inverter may provide nonlinear currents because of power converters connected as loads. The highly distorted currents may cause decline in the quality of its output voltage. Furthermore, the high voltage and current switching of the inverter generates harmonics which can be harmful to sensitive equipment. Therefore, the challenge of well-designed inverter is to maintain high quality sinusoidal output voltage under any load conditions. The key point to achieve such behavior is by designing appreciated controller with fast response. Nowadays, a dozens of control techniques have been proposed and applied to inverter systems. While, those controlling techniques have the same control objectives, they differ noticeably in terms of concept, design and approach. Some of controllers are simple in principle but may be difficult during implementation. Oppositely, other controllers require complex understanding of its principle, but its implementation can be relatively simple. Multilevel inverter is typically operated under a closed-loop controller in order to have the desired output voltage. Therefore, the choice of a suitable control strategy is very significant. The control strategy should be chosen based on the requirements of the system.

1.2 Problem Statement

Fuzzy Logic Controller (FLC) is linguistic based controller. FLC is operated based on rules obtained through designer's experience and knowledge about the system behavior. It exhibits excellent immunity to disturbances. As well as, it offers a high degree of freedom in tuning its control parameters. While, FLC has no standardized design procedure; the design is basically heuristic in nature. The heuristic approach is difficult because it deals with large number of rules and tuning parameters that has to be considered to obtain acceptable performance. Sliding Mode controller (SMC) is more robust performance, highly immune to any external disturbances and parameter changes. But, the practical realization of the controller is difficult. As well as, the SMC suffers from chattering phenomenon problem around the sliding surface which is caused by imperfection of switching and computation delay [4]. To diminish the chattering, fuzzy logic is introduced around the sliding surface. Firstly, the design method of the SMC is adopted to select both the membership functions and fuzzy inference rules. Then, the sliding surface is fuzzified to alleviate the chattering problem [5].

1.3 Objective

The objectives of the project are:

- To design, simulate, and analyze namely sliding mode controller and Fuzzy sliding mode controller applied to a 5-levels cascaded H-bridge.
- To compare the behavior of both controllers under different types of loads.

1.4 Scope

- The project scope will mainly focus on modeling, simulating and analysis Fuzzy Sliding mode Controller for Cascaded Multilevel Inverter using MATLAB/SIMULINK software
- Compare SMC with FSMC in term of the structure and their performance.
- Analysis of system behavior under verities of load disturbances.

1.5 Thesis Organization

In order to make the reader grabs the flow and the contents of this project; the report is organized into five chapters as following:

Chapter 1 talks about the research motivations to continue in this research. Research objectives are also presented. The scope of this project has been viewed as well. Chapter 1 also illustrates the thesis organization.

Chapter 2 focuses on the background and literature review of cascaded multilevel inverters and their controllers. Besides that, it expresses the concept of cascaded multilevel inverters and modulation techniques literature review in previous papers. In addition, the controlling strategies are generally stated for review. A background and basic information of sliding mode controllers, and fuzzy sliding mode controller are represented. Finally, a real life application of cascaded multilevel inverters with corresponding controllers are illustrated.

Chapter 3 will generally highlight the overall design parameters and derivations of the system equations. The mathematical of cascaded multilevel inverters is derived through state space equations and averaging technique. Then, sliding mode controller is designed based on derived mathematical representation of the system. A fuzzy logic controller is designed for the sliding surface. Lastly, the control signal equations for both controllers are obtained.

Chapter 4 will show the performance evaluations of system for both controllers under varieties of loads, compare the dynamic behavior of the controllers. Initially, the system and controllers parameters are shown in order to apply them into the loads. Then, the system with sliding mode controller is tested under full resistive, full wave rectifier, and Triac-controlled loads. The data for those tests are obtained. Fuzzy sliding mode controller is then tested for the same types of loads and system parameters. Finally, a compression between both controllers is provided to conclude this chapter.

Chapter 5 will summarize the system modeling and simulation result of the research. Also, it will conclude the result of compression between the two controllers. Recommendation and future work is suggested at the end.

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