CURRENT MODE FUZZY BASED CONTROLLER FOR MULTILEVEL INVERTER

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DEDICATION

This project report is dedicated to my beloved parents, my lovely wife and sons as well as to my sibling for their never-ending encouragement and support, who taught me not too easily surrender and feel defeated. Instead, keep up the challenge and feel the joy of the victory.

Not to forget to my mighty and respectful supervisor, lecturer and friend who give a valuable knowledge and help in this journey.

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ABSTRACT

Multilevel Inverter (MLI) has come to attention from industries for its practical and convenient solution especially in high power application. It produces staircase voltage waveform which gives more sinusoidal like waveform and as a result it has a lower THD percentage. Through the evolution in MLI topologies and advancement of power electronic devices, it become more viable technology and attracted wide interest for its number of advantages such as above. However, the selection of suitable switching technique to control the MLI has an effective and important role in generating an ideal output voltage that reduce the error as well as the harmonic content. A controller that been introduced into the system must has a characteristic of very fast and responsive, so that it will give more advantage to the MLI. This project will propose and design a current mode fuzzy based controller for five level cascaded multilevel inverter. It is a current mode-based control method offers good performance with faster response as compared to voltage mode control with an expense of additional current sensor. While, the employment of fuzzy control provides a better regulation performance with nonlinear load by manipulating the fuzzy logic structure through heuristic knowledge characteristic of the controller. Hence a system perform with tuneable controller is expected. To validate its performance, a simulation base on MATLAB/SIMULINK® will be conducted with a single phase five-level cascaded multilevel inverter where it been controlled by a proposed fuzzy controller in a current feedback loop. The results of the simulation were observed and analysed.

ABSTRAK

Penyonsang pelbagai aras (MLI) telah mendapat tumpuan oleh pihak industri kerana menyediakan penyelesaian yang lebih praktikal dan mudah terutamanya dalam aplikasi berkuasa tinggi. Ia menghasilkan gelombang berbentuk tangga yang memberi lebih banyak kesamaan kepada bentuk sinusoidal dan seterusnya menghasilkan peratusan THD yang lebih rendah. Melalui evolusi yang berlaku di dalam topologi MLI dan kemajuan peranti kuasa elektronik, ia telah menjadi MLI satu teknologi berdaya maju dan dapat menarik minat yang luas dari pihak industri kerana kelebihannya seperti di atas. Namun begitu, pemilihan teknik pensuisan yang bersesuian dalam mengawal keluaran MLI adalah berperanan penting dan berkesan dalam menghasilkan voltan keluaran yang ideal seterusnya dapat mengurangkan kesilapan dan kandungan harmonik. Pengawal yang diperkenalkan ke dalam sesuatu sistem haruslah mempunyai ciri yang sangat cepat dan responsif. Ini akan memberi banyak kelebihan kepada MLI. Projek ini mengusulkan dan merekabentuk kawalan berasaskan logik kabur arus untuk penyonsang pelbagai aras (MLI). Ia berdasarkan kaedah kawalan berasaskan mod arus yang mana menawarkan prestasi yang baik dengan tindak balas yang lebih cepat berbanding kawalan berasaskan mod voltan dengan tambahan kos sensor aliran. Sementara itu, penggunaan kawalan logic kabur menyediakan prestasi peraturan yang baik terhadap beban tidak linear dengan memanipulasi struktur logik kabur melalui pengetahuan heuristik pengawal. Oleh itu, prestasi pengawal yang lebih mudah diserasikan dengan penalaan adalah dijangka. Untuk mengesahkan prestasi pengawal tersebut, simulasi berasas kepada MATLAB / SIMULINK® akan dijalankan dengan dengan menggunakan aliran kuasa satu fasa terhadap lima peringkat penyonsang pelbagai aras yang dikawal oleh pengawal logik kabur menggunakan kaedah maklum balas aliran arus. Keputusan simulasi akan dikaji dan dianalisa.

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LIST OF ABBREVIATIONS

MLI	-	multilevel inverter
THD	-	total harmonic distortion
PI	-	proportional integral
FLC	-	fuzzy logic controller
DC	-	direct current
VSI	-	voltage source inverter
CSI	-	current source inverter
NPC	-	neutral point clamped
PWM	-	pulse width modulation

LIST OF SYMBOLS

V_{dc}	-	Direct current voltage
S	-	Switching
V_o, v_o	-	Output voltage
v_{tri}	-	Triangular voltage, carrier voltage
v_{sine}	-	Reference voltage, sine waveform
K_p	-	PI proportional gain
K_i	-	PI integral gain
e	-	Error
Δe	-	Change of error

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Fuzzy Logic is one of logic form which has more than two (2) logics value as contras to Boolean Logic. Boolean Logic depends on two specific value of completely true (1) and completely false (0). As oppose to that, the logic value of Fuzzy logic can be fall on partially truth where the value may be in the range between of both one (1) and zero (0). This can be achieved by introduction of linguistic variable for a certain range, impose in a certain membership group or function. This function is made through the knowledge that been gathered and verified and uses the degree of truth in a mathematical model. Thus, process of fuzzification and defuzzification involved in a process that link between the input and the output of a system will be made according to the rule which been defined. The concept that been introduced by Prof Lofti Zadeh in 1965 is designed to mimic the way of human thinking in solving problem. This process can be simplified as in Figure 1.1.

For its flexible variables mapping based on the knowledge given, the Fuzzy logic has been used in many fields and mostly in a wide variety of controllers as well as in feedback systems. It allows engineer to exploit their empirical knowledge and fuzzy heuristic capability which can be represented in the IF-THEN rules and then transfer it to a functional block [12].

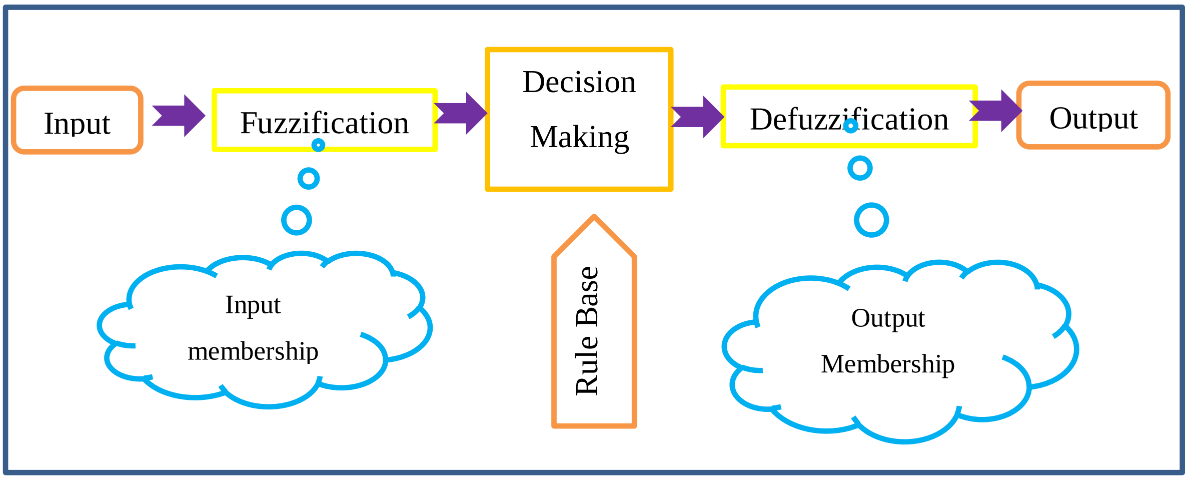

Figure 1.1: Block diagram of FLC

While multilevel inverter (MLI) is an inverter that convert dc sources to a desired sinusoidal ac output voltage through certain topologies or method where the number of the dc sources determine the step level of output staircase waveform. The dc sources may be obtained from batteries, fuel cell, or even a renewable energy system. Its application suitable in high voltage and high power industries such as photovoltaic solar system as well as wind turbine generation system. It has widely acceptable and becoming popular due to its advantages [13]. The minimum required switching frequency of the MLI has increased its efficiency and since the THD percentage is very low as result of low harmonic distortion, it contributes to the improvement in power quality and dynamic stability in power system. This is highly been regarded in power utility system.

Since, the quality of the output voltage produced by an inverter is paramount in determined the stability of the power system and the harmonic distortion that may result in serious effect to sensitive equipment. [11], several controllers have been proposed in order to improved efficiency and eliminating harmonic content in MLI topologies. Therefore, in this paper, for a Multilevel Inverter application, current base Fuzzy logic controller will be implemented as an alternative method. It will be verified through comparison of its robustness and response time against a PI controller.

1.2 Problem statement

Several PI controllers have been successfully integrated into multilevel inverter system as a mean to regulate the required output. Despite that, PI requires complicated and complex mathematical modelling to represent the actual system and seldom successfully control for large signal model.

This paper will look into the possibility of using a Fuzzy Logic Controller (FLC) as an alternative controller to the existing PI controller of MLI. And thus, to study its advantages in small and large signal model

1.3 Objectives

In order to achieve the aim of the study, the research proposal has the following objectives: -

1) To design a closed-loop control employing current mode fuzzy base controller for multilevel converter system
2) To analyse the performance of the purposed system

1.4 Scope of study

The scopes of the project give limitations and boundaries to the project in order to achieve its target. It to ensure the development of the project is within its boundaries while heading to the direction in fulfilling the objectives. There are several scopes indicated as follow: -

1) The project will focus on the proposing of closed-loop feedback by using proposed Fuzzy controller in a current feedback loop
2) It will be conducted with a single phase five-level cascaded multilevel inverter.

3) To measure and to test its workability and functionality by using MATLAB/SIMULINK®.
4) Simulation will be carried in small power system

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