

# Chapter 11

## Approximated Simplest Fuzzy Logic Controlled Shunt Active Power Filter for Current Harmonic Mitigation

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### **ABSTRACT**

*This paper examines the size reduction of the fuzzy rule base without compromising the control characteristics of a fuzzy logic controller (FLC). A 49-rule FLC is approximated by a 4-rule simplest FLC using compensating factors. This approximated 4-rule FLC is implemented to control the shunt active power filter (APF), which is used for harmonic mitigation in source current. The proposed control methodology is less complex and computationally efficient due to significant reduction in the size of rule base. As a result, computational time and memory requirement are also reduced significantly. The control performance and harmonic compensation capability of proposed approximated 4-rule FLC based shunt APF is compared with the conventional PI controller and 49-rule FLC under randomly varying nonlinear loads. The simulation results presented under transient and steady state conditions show that dynamic performance of approximated simplest FLC is better than conventional PI controller and comparable with 49-rule FLC, while maintaining harmonic compensation within limits. Due to its effectiveness and reduced complexity, the proposed approximation methodology emerges out to be a suitable alternative for large rule FLC.*

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## INTRODUCTION

In the recent decades, the applications of semiconductor devices have increased manifold due to their numerous advantages such as better controllability, higher efficiency, fast switching and better current handling capacity. But at the same time their inherent nonlinear characteristics introduce many undesirable features in the system, such as harmonics, poor voltage regulation, poor power factor, low system efficiency, and interference in nearby communication system etc. All these undesirable features affect the power quality. Shunt passive filters were traditionally used to provide current harmonic compensations. But these passive filters suffer from certain demerits such as fixed compensation, large size, detuning problems due to aging effect and resonance as pointed out by Singh, Al-Haddad, and Chandra (1999) in their review paper on active filters for power quality improvement. Shunt active power filters (APF) have emerged as an undisputed alternative over their passive counterparts for current harmonics mitigation and reactive power compensation.

The voltage source inverter (VSI) based shunt APF is preferred for harmonic and reactive power compensation as discussed by Akagi, Kanajawa, and Nabae (1984), Peng, Akagi, and Nabae (1990), Grady, Samotyj, and Noyola (1990), Singh, Chandra, and Al-Haddad (1999), and Singh, Al-Haddad, et al. (1999). A control scheme is proposed by Dixon, Contrado, and Morán (1999) which require sensing of line currents only for generation of reference current. The scheme is simple and easy to implement. Recently most of the reported work uses this scheme, which includes the papers of Jain, Agrawal, and Gupta (2002) on control of shunt APF using fuzzy logic controller (FLC) and Mishra and Bhende (2007) on bacterial foraging based optimized based control of shunt APF.

Artificial intelligence (AI) is getting popularity among control engineers due to its ability to handle complex problems at randomly varying operating conditions. Bose (1994) in his invited

paper has explored the possibilities of expert system, fuzzy logic and neural network applications in power electronics and motion control. This work has provided a new space of opportunities for control engineers. Anis Ibrahim and Morcos (2002) focus on the effectiveness of AI and advanced mathematical tools for power quality applications. A fuzzy logic based shunt APF shows better dynamic response and higher control precision as compared with the PI controller as concluded by Dixon et al. (1999), Jain et al. (2002), An, Zhikang, Wenji, Ruixiang, and Chunming (2009), and Karuppanan and Mahapatra (2011). All these papers have proposed 49-rule FLC for the control of shunt APF. The 49-rule FLC has the drawback of a large number of fuzzy sets and control rules. Due to this the complexity of the controller increases, as large computational time and large memory is required to execute the desired control action. This drawback is overcome in this paper by approximating a 49-rule FLC with a simplest 4-rule FLC.

In the recent past some studies regarding reduction of rule base size have been reported. Bezzine, Derbel, and Alimi (2002) explained some issues on design and rule base size reduction for the fuzzy control of robot manipulators. Ciliz (2005) explained some concepts regarding resizing of rule base by removing inconsistent and redundant rules for the application of vacuum cleaner. These two studies were application specific. Hampel and Chaker (1998) provided some conclusions for minimization of number of variable parameters for optimization of fuzzy controller. Moser and Navrata (2002) proposed a fuzzy controller with conditionally firing rules, in this work number of rules were not minimized only the conditions under which they will fire were reduced. Zeng and Singh (1994, 1995) proposed a mathematical description of approximation theory of fuzzy systems for single input single output (SISO) and multi input multi output (MIMO) cases. The main focus of these papers was the approximation capabilities of the fuzzy systems for approximat-

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