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Shunt Active Filter Controlled by Fuzzy Logic

Hocine Benalla and Hind Djeghloud
Electrotechnics Laboratory, Engineer Sciences Faculty, University of Constantine, Algeria
E-Mails: benalladz@yahoo.fr, hinddjeghloud@yahoo.fr

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Abstract. Harmonics contamination is a serious and a harmful problem in electric power systems. Active power filtering constitutes one of the most effective proposed solutions. A shunt active power filter that achieves low current total harmonic distortion THD, reactive power compensation, and power factor correction is presented. The topology is based on IGBT's voltage inverter, intended to damp harmonics produced by a diode rectifier. The main paper's contribution is the use of the notch filter method, consisting solely of two serial band-pass filters, for reference currents calculation, and the application of fuzzy logic for better active filter current control accuracy. The gating signals were generated through the carrier-based PWM strategy. Simulation works of the studied model, using SIMULINK under MATLAB software, revealed satisfying results in transient and steady states.

Keywords: Harmonics, Shunt active power filter, Band-pass filters, Fuzzy logic, PWM strategy.

Introduction

The wide use of power devices based on semi-conductor switches in power electronic applications (diode and thyristor rectifiers, electronic starters, UPS and HVDC systems, arc furnaces, etc…) induces the appearance of the dangerous phenomenon of harmonic currents flow in the electrical feeder networks, producing distortions in the current/voltage waveforms. As a result, harmful consequences occur: equipment overheating, malfunction of solid-state material, interferences with telecommunication systems, etc... Damping harmonics devices must be investigated when the distortion rate exceeds the thresholds fixed by the ICE 61000 and IEEE 519 standards. For a long time, tuned LC and high pass shunt passive filters were adopted as a viable harmonics cancellation solution [1]. However, insufficient passive filter characteristics or even resonant amplification of harmonics due to mistuned components on the one hand, and the decreasing costs of power electronics devices on the other hand, increased interest in two or multilevel shunt, series and hybrid active power filters (APF's), which besides

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their capability to cancel harmonics with minimum drawbacks, contribute in the reactive power compensation, power factor correction and DC voltage regulation [2-7]. Although series APF's offer reduced rated power capacity and filtering characteristics, they present the disadvantages of difficulty to protect against power system anomalies and the need to be connected to passive LC filters in order to operate correctly [2]. On the other hand, shunt APF's are not disturbed by power distribution anomalies and the compensation of the power factor as well as current harmonics can be easily implemented [3]. The notch filter is a very simple method allowing the APF's current reference extraction without need to active/reactive power or any complicated calculations. The design of a control able to pursue current peaks isn't straightforward. But, this difficulty has been overwhelmed by the introduction of fuzzy logic in power electronic field. In fact, with fuzzy logic it's possible to design a control system adjusting the control surface for very different working conditions, so the control can follow the reference current even when very high peaks occur. Besides, DC capacitor's voltages can be maintained at constant levels with fuzzy control [8-10].

This paper deals with a shunt active power filter topology that achieves simultaneously harmonic current damping, reactive power compensation, and power factor correction. For the APF's reference current computation we use the notch filter method, and for gating signal generation we apply the carrier-based PWM modulation. The fuzzy control consists of converting classical LPF correctors to fuzzy ones, improving the system dynamic. Simulation studies were carried out using SIMULINK under MATLAB software.

Shunt Active Power Filter Modeling

Principle

An active power filter is a converter (inverter), placed between the power supply and the receiver, which absorbs the whole or part of the disturbances generated by the said receiver [11, p. 330]. If we denote i_{ca}, i_{cb}, i_{cc}, the receiver absorbed currents, and i_{sa}, i_{sb}, i_{sc}, the desired power supply currents, then the active filter must provide currents i_{fa}, i_{fb}, i_{fc}, given by:

$$i_{fa} = i_{ca} - i_{sa} \qquad i_{fb} = i_{cb} - i_{sb} \qquad i_{fc} = i_{cc} - i_{sc} \tag{1}$$

so that:

- The currents taken from the power supply are sinusoidal;
- The fundamentals of these currents are in phase with the supply voltages;
- The currents meet these two conditions simultaneously.

The example of harmonic load considered in this paper is a three-phase uncontrolled diode bridge rectifier as shown in Fig. 1.

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