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Recursive Integral with Fuzzy Control Method used in Shunt Hybrid Active Power Filter

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Abstract

A current control method for a shunt hybrid active power filter (HAPF) using recursive integral algorithm is presented in this paper. The method improves performance of the HAPF system by reducing the influence of detection accuracy, time delay of instruction current calculation and phase displacement of output filter. Fuzzy logic based set-point weighing algorithm is combined in the control scheme to enhance its robustness and anti-interference ability. The proposed algorithm is easy for engineering application and has small computation capacity. Experiment results have verified the validity of the proposed controller. Furthermore the proposed recursive integral PI algorithm can also be applied in the control of periodic current as in AC drivers.

Keywords: harmonic suppression; reactive power compensation; recursive integral PI; fuzzy inference

1. Introduction

With the wide use of power electronics-related appliances in industry, harmonics problem is more and more serious. Harmonics not only influence the normal work state of electric equipments, but also interfere communication equipments. At present, passive power filter (PPF), active power filter (APF) and hybrid active power filter (HAPF) are mostly used to eliminate the harmonics [1]–[3].

In order to control the inverter to produce a current which is equal on the amplitude and opposite in direction with the load harmonic current, a current control method is required. But due to the influence of detection accuracy, time delay of instruction current calculation and phase displacement of output filter, the harmonic currents are difficult to be acquired accurately, therefore the performance of the HAPF

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system is not so good [4]. Many papers which focus on obtaining the harmonic currents for APF have been published to resolve the problems. Asynchronous frame proportion integral (SFPI) [5] and self-adapting filtering technique [6] are reported, but they both have their respective disadvantages. SFPI will rotate every order harmonic, many frames will be created making the calculation intricacy, the control period will be lengthened and the switch frequency will be limited too. Self-adapting filtering technique relies on the accuracy of the reference current. Furthermore most proposed methods used to obtain the control reference signal require several high precision analog multipliers or a high speed digital signal processing chip with fast A/D chip, it will result in a complex circuitry, so they are mostly difficult to be realized.

This paper proposed a new method using recursive integral algorithm for a shunt hybrid active power filter to improve its steady-state and dynamic performance. The proposed algorithm is easy for engineering application and has small computation capacity. Fuzzy logic based set-point weighing algorithm is combined in the control scheme to enhance its robustness and anti-interference ability. A prototype was developed to demonstrate the performance of the proposed HAPF and the control scheme. Experiment results have verified the validity of the proposed control method.

2. Description of the System

HAPF system is composed of PPF and APF, as shown in Fig. 1, T stands for coupling transformer, L1 and C form into output filter. APF is used to improve the effect of PPF and restrain the resonance made by PPF. The compensation characteristics of PPF are selected according to the characteristic harmonics needing to be compensated. This paper chooses 5 and 7 single-tuned filters and a second order high pass filter in allusion to the harmonic source of three-phase diode full-bridge rectifier. Coupling transformer is used to realize electric isolation and make the voltage of inverter match up to the current. Output filter eliminates switch harmonics made by switching power equipments.

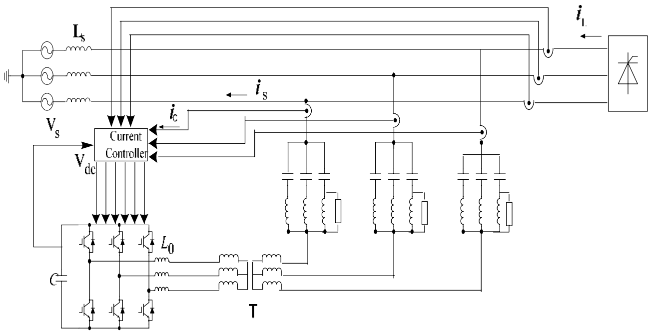

Fig. 1. System configuration of the HAPF

Control system for the HAFP system is shown in Fig2. In Fig2 i_{cx}^* and i_{cx} respectively stand for the x phase's compensate current and its reference value, while i_{sx}^* for source reference current; v_{dc} and v_{dc}^* respectively denote the dc side voltage of PWM inverter and its reference value while i_{Lx} and i_{Lf} respectively the load current and load fundamental current gained by i_p, i_q theory; i_{REF} represents the reference signal needed buy the inverter. It is made up of current control inner loop and voltage control outer loop, current loop is used to control current, while voltage loop maintain the dc-link voltage to enhance the inner loop's performance. The reference current of inverter can be obtained from

$$i_{cx}^* = i_{sx}^* - i_{Lx} \quad (1)$$