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RESEARCH ARTICLE

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Power quality improvement using fuzzy logic controller for five-level shunt active power filter under distorted voltage conditions

Abstract In this paper, a five-level inverter is used as a shunt active power filter (APF), taking advantages of the multilevel inverter such as low harmonic distortion and reduced switching losses. It is used to compensate reactive power and eliminate harmonics drawn from a thyristor rectifier feeding an inductive load (RL) under distorted voltage conditions. The APF control strategy is based on the use of self-tuning filters (STF) for reference current generation and a fuzzy logic current controller. The use of STF instead of classical extraction filters allows extracting directly the voltage and current fundamental components in the α-β axis without phase locked loop (PLL). The MATLAB fuzzy logic toolbox is used for implementing the fuzzy logic control algorithm. The obtained results show that the proposed shunt APF controller has produced a sinusoidal supply current with low harmonic distortion and in phase with the line voltage.

Keywords active power filter (APF), harmonics isolator, distorted voltage conditions, self-tuning filters (STF), fuzzy logic control

1 Introduction

The extensive use of static converters in industrial activities and public consumers leads to an increase in harmonic injection in the network and a lower power factor. This causes various problems in power systems and in domestic appliances such as equipment overheating, capacitor blowing, motor vibration, excessive neutral currents and low power factor.

Active power filter (APF) involving two levels voltage source inverters have been widely studied and used to eliminate harmonics and compensate reactive power [1]. Due to power handling capabilities of power semiconductors, these APFs are limited in medium power applications. Then hybrid topologies have been proposed to achieve high power filters [2,3]. Recently, the interest in using multilevel inverters for high power drives, reactive power and harmonics compensation has increased [4]. Multilevel pulse width modulation inverters can be used as APF for high power applications to solve the problem of power semiconductor limitations. The use of neutral-point-clamped (NPC) inverters allows equal voltage shearing of the series connected semiconductors in each phase. The performances of different reference current generation strategies under balanced, sinusoidal, alternating current (AC) voltages conditions are well referenced [5,6], such as the so-called p-q theory and synchronous reference frame theory (SRF) which provide similar performances. Differences arise when one works under distorted and unbalanced AC voltages which is the case in real conditions, where the mains voltages are distorted that decreases filter performances [7].

In this paper, the reference current generation for shunt APF control under distorted voltage conditions is based on the use of STFs. The STF is used to extract the fundamental component directly from electrical signals (distorted voltage and current) in the α-β reference frame under distorted voltage conditions [8].

The major advantages of the STF are efficient operation under steady state and transient conditions; no phase delay and unity gain at the fundamental frequency; no PLL

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