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Hybrid Active Power Filter: Design Criteria

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Abstract-The configuration of a series active power filter (APF) and a parallel passive filter (PPF) has proven to be an efficient system for nonlinear load compensation. For this topology, different compensation strategies have been proposed to control the series APF. The most effective strategy determines the APF refrerence voltage as a proportion of the source current harmonics. The proportionality constant in the control algorithm implementation is related to the APF gain and the system dynamics. In this paper, the system state model has been obtained for three control strategies of series APF: voltage proportional to source current harmonics, voltage opposite to the load voltage harmonics and a hybrid strategy which combines both previous. The resulting model analyses provide the information needed to establish design criteria for each strategy, both in terms of harmonic filtering and the system stability. The three strategies were compared in two different situations: sinusoidal supply voltages and distorted supply voltages. Finally, results of an experimental prototype developed for this purpose allowed the proposed analysis to be verified.

Key words
Power quality, active filters, hybrid filters, harmonics, state model.

1. Introduction

Active power filters (APF) have shown to be an effective technology to eliminate harmonics and to compensate nonlinear loads [1-3]. The shunt connection has been the most studied topology, where the APF is connected in parallel with the load. One of its traditional uses is the elimination of current harmonics produced by loads which generates such disturbances, this is HCS loads (Harmonic Current Source) [4,5]. However, the parallel APF is not suitable in situations where the load generates voltage harmonics, HVS loads (Harmonic Voltage Source). In this case, series connection APF configuration has been proposed and different control strategies have been tried out [6].

Compensation systems composed only of an APF either shunt or series connection do not solve completely the problem of harmonic elimination for all load types. So, other configurations have been proposed [1]. They combine series and parallel topologies, active and passive filters.

Among the hybrid topologies, the series APF with parallel passive filter (SAPPF) is the most studied. Specifically for this configuration, different control strategies have been proposed. One of them has its origin in the early 90s; the control objective was based on generating a voltage proportional to the source current harmonics. This APF control strategy allowed to improve the filtering features of parallel connection passive filter [7]. The functionality of the new strategy is analyzed from a steady state model; however, this theoretical development is not suitable to study the system stability or to determine the proportionality constant value.

Subsequently, other control strategies for the series APF appeared. Thus, in [8-10] three control strategies are analyzed

In this paper the theoretical analysis of a hybrid filter constituted by a series APF and shunt passive filter is carried out. For this, the state model equations are obtained from its single phase equivalent circuit. The behaviour of compensating equipment is analyzed for three different control strategies:

- Source current detection (SCD). In this strategy, the filter generates a voltage proportional to the source current harmonics.
- Load voltage detection (LVD). In this strategy the active filter generates a voltage opposite to the load voltage harmonics.
- Current and voltage detection (CVD). This strategy combines the source current detection and the load voltage detection.