# Comparison of Active Filters Topologies in Medium Voltage Distribution Power Systems

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***Abstract*--This paper presents the design of different topologies of active power filters to compensate reactive power and harmonics in the medium voltage level of a distribution power system. One pure active filter and two hybrid topologies, are implemented. A pure active compensation is obtained with a Shunt Active Power Filter (SAPF). The shunt combination of SAPF and passive filter, form one of the hybrid topologies implemented, named Shunt Hybrid Active Power Filter (SHAPF). The other hybrid topology, called Hybrid Shunt Active Power Filter (HSAPF), connects the active filter in series with two shunt passive filters. Simulation for different load demands and distortions are performed. Finally a comparative evaluation of the different filters is carried out.**

***Index Terms*--Active Filters. Distribution Power System. Harmonics. Power Quality. Reactive Power.**

## I. Introduction

Non-linear loads and equipments in the consumer side and renewable energy sources in the generation side are defining the need of power electronics as an essential interface in power systems to improve Power Quality [1][2]. Voltage distortion, due to current harmonics, has become a major problem for the utilities at distribution levels. Utilities frequently encounter harmonic related problems, such as higher transformers and line losses, reactive power, and resonance problems, de-rating of distribution equipment, harmonic interactions between the utility and loads, reduced system stability and reduced safe operating margins [1][3].

The use of traditional compensation with capacitor banks and passive filters gives rise to harmonic propagation. That is harmonic voltage amplification due to resonance between line inductances and shunt capacitors. So, different active solutions have been continuously analyzed in the last years [4]-[7]. A lot of research has been followed on different topologies to improve Power Quality [8]-[10].

Among all this compensation alternatives the hybrid topologies which use passive and active filters result very attractive in distribution power systems where some passive compensation is already installed [11]-[14]. Such a combination between active and passive filters allows reducing significantly the rating of the active filter, since its main task is to improve the filtering performance and to avoid the resonance problems introduced by passive filters. In this way it constitutes a simple and cheap solution for harmonics in distribution power systems.

A particular problem of an actual distribution power system is considered in this paper. Reconfiguration of the system imposes new constraints in different distribution substations (DS). Harmonic studies were performed considering the future configuration of the system. Voltage distortions at 13.8 kV busbar of the system and the working conditions of the capacitor banks were verified by means of harmonic flows [15]. A preliminary proposal suggested increasing the existing passive compensation with capacitor banks from 4.8 Mvar to 9.6 Mvar, but this solution introduced resonances near the 5$^{th}$ and 7$^{th}$ harmonics resulting in unacceptable distortion levels. Three active topologies connected to the medium voltage level of DS (SAPF, SHAPF and HSAPF) are proposed here to solve the particular problem of reactive power and harmonics compensation.

The paper is organized as follows. The system configuration and the harmonic problems are described in section II. The different topologies and their design are presented in section III to V. Their performances are evaluated in section VI. Finally conclusions are drawn in section VII.

## II. System Description

The 132 kV system, where the DS under study are connected, works meshed and connected to the 500 kV high voltage transmission system. In the future, the requirement to enhance the voltage profile at 13.8 kV level demands for new compensation in the different substations [15].

Fig. 1 shows the one line diagram of the system model adopted for the DS under test. The system is represented as an ideal voltage source of 132 kV connected to three transformers of similar characteristics, 132/34.5/13.8 kV and 15/10/15 MVA. The system is modeled by an equivalent impedance related to short circuit power at 13.8 kV. The short circuit power at 13.8 kV is approximately 200 MVA. There are no loads at the 34.5 kV level. All transformers are connected in parallel to 13.8 kV where the capacitor banks and the loads are placed. Feeders, underground cables and overhead lines, are considered at the load connection.

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