DESIGN, ANALYSIS AND SIMULATION OF COMPOSITE FILTER FOR PQ ISSUES IN DISTRIBUTION NETWORK

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ABSTRACT

In recent years, voltage and current harmonics have become a serious problem both in transmission and distribution systems, due to the widespread usage of non-linear loads such as diode/thyristor rectifiers, electric arc furnaces and motor drives. Voltage and current harmonics, which are injected in the utility by non-linear loads, cause major problem that tend to deteriorate the power quality at PCC. To reduce such harmonics, PFs are commonly employed. With diverse applications involving reactive power together with harmonic compensation, passive filters are found suitable due to low cost, simplicity, reliability and control-less operation. In order to obtain a better performance than those of the conventional passive filter solutions, APF have been worked on, developed and simulated. Among various configurations listed in the literature, conventional shunt connected voltage source active power filter is widely used in industrial applications. Unfortunately, for large power applications, the losses and the rating of the APF increase considerably. As a result, various composite/hybrid filter topologies have been developed which combine the advantages of both passive and active filters.

This thesis presents design, analysis and simulation of a CF for targeting the power quality issues in distribution network. The distribution network consists of non-linear load such as Electric arc furnaces, DC rectifiers, DC drives etc. The increasing popularity of electric arc furnace in metallurgical industries to melt scrap causes significant impacts on power system and electrical power quality. EAF is one of responsible source for

deteriorating the power quality in the network by introducing odd & even harmonics, propagating voltage flickers and causing voltage unbalance. Hence an EAF is chosen as an industrial non-linear load to demonstrate power quality problems. Literature Survey shows that majority efforts are put to model EAF either from voltage flicker point of view or from harmonics point of view. Few models are found with combination of harmonic as well as voltage flicker. Therefore, an effort is made to propose a novel EAF model using transition function to demonstrate typical EAF with its harmonic, voltage flicker and unbalanced behavior together using combination of Exponential and Hyperbolic VIC. Performance of the proposed EAF model is analyzed and compared with that of existing Cassie-Mayr EAF Model for validation along with real data available.

The distribution network along with the EAF has been simulated. The distribution network is analyzed from power quality point of view keeping IEEE 519-1992 Standards in view. At first passive filter has been designed to compensate current and voltage harmonics. The drawback associated with the PFs is tried solve by a connecting series active power filter along with the passive filter-thus forming a CF. The composite filter consists of a small rated series active power filter and a shunt passive filter. This composition is suitable for compensating voltage type harmonic producing loads-such as an electric arc furnace. The reference signal of the compensation voltage needed by the series APF is obtained by detecting both source current and load voltage. This strategy improves the passive filter compensation characteristics without depending on the system impedance and avoiding the series/shunt resonance problems.

A state-space averaging model of proposed composite filter is constructed to analyze its system stability by proposed control strategy. The stability of the series APF based on feedback control is discussed theoretically, taking into account time delay in the proposed control circuit. The system stability is analyzed in frequency domain in terms of gain margin and phase margin. It is revealed that the delay time produce a bad effect on stability when the power converter is installed on a power system with low system inductance.

Simulation for a typical distribution network with a composite power filter has been carried out to validate the performance. The simulations have been carried out in MATLAB environment using SIMULINK and power system block set toolboxes. In this research work,

composite filter performance in 3-Φ, 3-wire distribution network under various load conditions- refining cycle, melting cycle considering sinusoidal flicker, melting cycle considering random flicker and unbalance load voltages is carried out. The proposed composite filter performs satisfactorily for various load conditions such as refining cycle, melting cycle and unbalance with overall reducing rating of the filter. The present work is likely to contribute significantly to the area of power quality enhancement. This proposed scheme has resulted in improved power quality of EAF distribution network.