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Simplified Control Method for Unified Power Quality Conditioner (UPQC)

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Abstract. Unified Power Quality Conditioner (UPQC) for harmonic elimination and simultaneous compensation of voltage and current, which improves the power quality offered for other harmonic sensitive loads. UPQC consist of combined series active power filter that compensates voltage harmonics of the power supply, and shunt active power filter that compensates harmonic currents of a non-linear load. In this paper a new control algorithm for the UPQC system is optimized and simplified without transformer voltage, load and filter current measurement, so that system performance is improved. The proposed control technique has been evaluated and tested under dynamical and steady state load conditions using PSIM software.

Key words

Unified Power Quality Conditioner (UPQC), harmonics, active power filter, power quality.

1. Introduction

Unified power quality control was widely studied by many researchers as an eventual method to improve power quality of electrical distribution system [1-3]. The function of unified power quality conditioner is to eliminate the disturbances that affect the performance of the critical load in power system. In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems. The UPQC, therefore, is expected to be one of the most powerful solutions to large capacity loads sensitive to supply voltage flicker/imbalance [2].

In this paper, the proposed control algorithm for the UPQC is optimized and simplified without transformer voltage, load and filter current measurement, so that system performance is improved. The proposed control technique has been evaluated and dynamically tested under different load conditions using PSIM software.

2. Unified Power Quality Conditioner

Fig. 1 shows a basic system configuration of a general UPQC consisting of the combination of a series active power filter and shunt active power filter. The main aim of the series active power filter is harmonic isolation between a sub-transmission system and a distribution system; it has the capability of voltage flicker/ imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer point of common coupling (PCC). The shunt active power filter is used to absorb current harmonics, compensate for reactive power and negative-sequence current, and regulate the dc-link voltage between both active power filters.

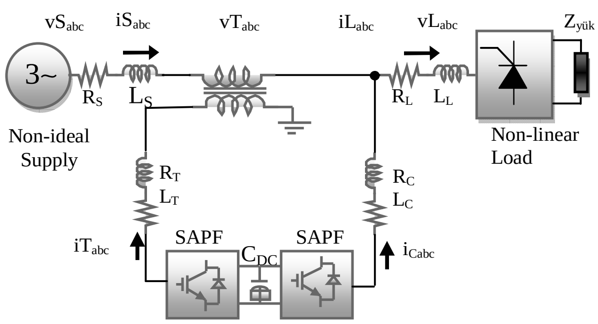

Fig. 1. Unified Power Quality Conditioner configuration.

3. Simulation and Experimental Results

In this study, a new simplified control algorithm for UPQC is evaluated by using simulation results given in PSIM software. The proposed control algorithm has considerably good simulation results as compared the conventional control algorithms.

In the proposed control algorithm, load currents (i_{Labc}), mains currents (i_{Sabc}), mains voltages (v_{Sabc}) and load voltages (v_{Labc}) waveforms are shown in Fig. 2, before and after UPQC system is operated.

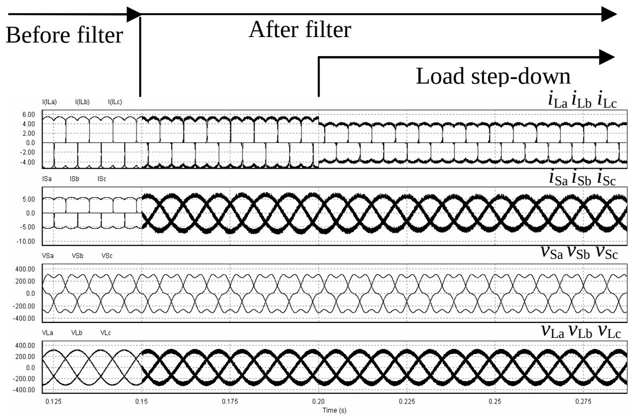

Fig. 2. Mains-load current and voltage waveforms when UPQC system is operated.

The feasibility of hardware implementation for the proposed control algorithm was evaluated by design and experimentation of three-phase three-wire UPQC. A three-phase diode-bridge rectifier with the R-L load as the nonlinear load is connected to AC mains to demonstrate the effectiveness of the UPQC with the proposed method.

Fig. 3 shows source voltage and current waveform before filtering. After compensation, source current becomes sinusoidal and in phase with the source voltage; hence, both harmonics and reactive power are compensated simultaneously. Before harmonic compensation the THD of the supply current was 29.13% and after the harmonic compensation, it was reduced to 5.75% which complies with the IEEE 519 harmonic standards.

In three-phase form source current experimental results for proposed control of shunt active power filter part of UPQC system are shown in Fig. 4 before and after filter operated. These experimental results given above shows that the power quality compensation features of UPQC, by appropriate control of shunt APF can be done effectively. The experimental laboratory prototype series active power filter part is installing and experimental results are planning to publish in future papers.

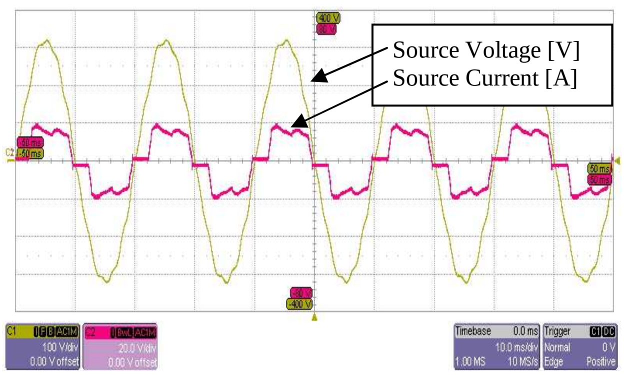

Fig. 3. Experimental results for source voltage (v_{Sa}) and source current(i_{Sa}) before filter operation.

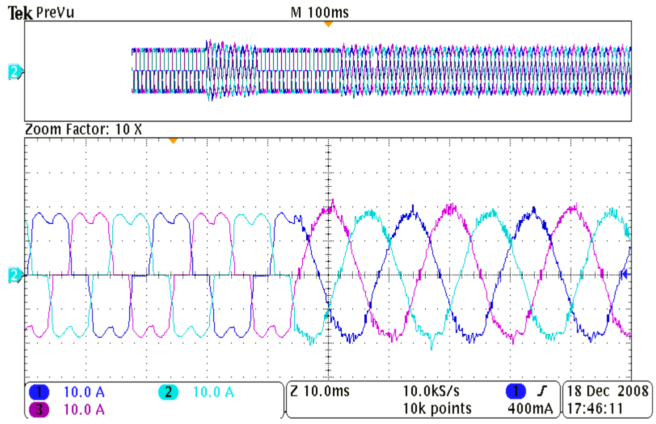

Fig.4. Experimental results for source currents (i_{Sabc}) before and after filter operation.

4. Conclusion

In this study, a new simplified control algorithm is proposed for UPQC system in order to compensate power quality problems such as, unbalanced voltages, harmonics, reactive power and neutral current of the nonlinear loads. The proposed control algorithm simulation results are given in PSIM simulation. In literature, conventional UPQC control algorithms require measurements of load, filter and mains currents and voltages and also DC bus voltage in order to regulate DC bus. The proposed control algorithm, the number of measurement is decreased. In this study successful simulation results are given in PSIM simulation software. The laboratory prototype experimental results for shunt active filter part are given.

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