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Abstract

OPERATION AND DC-LINK VOLTAGE CONTROL OF
THREE-PHASE FOUR-WIRE UNIFIED POWER
QUALITY CONDITIONERS

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This thesis proposes a three-phase four-wire unified power quality conditioner (UPQC) control algorithm and its dc-link voltage feedback control. UPQC is the integration of series and parallel active filter interconnected with dc-link. UPQC can enhance the power quality in both source and load side, such as voltage flicker, sag, swell, and reactive current, neutral current and harmonics. It is composed by a series active power filter (SAPF) and parallel active power filter (PAPF), with a common dc-link capacitor. The SAPF is responsible for cancellation of voltage imbalance, flicker, sags and swells, and provides stable, balanced and sinusoidal voltages to the loads. The PAPF is used to compensate the imbalance, reactive power, neutral current and harmonics of the source currents. In UPQC, the dc-link power needed to be controlled such that the dc storage capacitor can maintain a uniform dc voltage.

In order to control coordinate the SAPF and PAPF control of the UPQC system efficiently, the concept of instantaneous power theory is applied in the control algorithms and analysis of the system. In this thesis, three different instantaneous power coordinates and control algorithms, including $a-b-c$, $\alpha-\beta-0$ and $p-q-r$ coordinates, are studied and compared. To further improve the source current THD

and reduces the dc-link voltage fluctuation under unbalanced system voltages, a novel p - q - r sinusoidal adjusting compensation scheme is proposed.

With the integration of the SAPF and PAPF, the dc-link voltage of the UPQC is required to be regulated. With the analysis of instantaneous active power flow of the UPQC system, a feedback controller can be added with the absorption of active current in the PAPF as feedback path. The relationship between the instantaneous active flow and the dc-link voltage is studied, and the corresponding mathematical model of the UPQC system is proposed. Based on the transient analysis of the UPQC system model, a novel dynamic pole placement algorithm in the application of UPQC dc-link feedback control is proposed. The proposed algorithm reduces the transient dc-link voltage variation and the source current magnitude fluctuation without additional control circuitry.

In this thesis, the relationship between the instantaneous active power, dc-link capacitance and compensation capability in unified power quality conditioner (UPQC) is investigated. The dc-link voltage can be regulated by increasing the dc-link capacitance, however, this will also increase the system cost. The dc-link voltage can also be controlled by PI controller but may also introduce harmonics to the compensated currents. The corresponding minimum dc-link capacitance is proposed in terms of the dc-link voltage variation and feedback controller parameters.

With the implementation of the control algorithms, and proper designs of the SAPF and PAPF system architectures and software controls, an experimental system of UPQC is built. The experimental system configurations and the system parameters design are introduced. Detail implementation of the SAPF and PAPF control algorithms in the DSP controller are given. The compensation capability of the load voltages and source currents with the experimental UPQC system is demonstrated with recorded waveforms. To verify the dc-link voltage feedback control and the proposed dynamic pole placement algorithm for UPQC, the transient responses of the UPQC system with and without the proposed dynamic pole placement algorithm are compared and discussed with the experimental data and waveforms.