Agata Bielecka

Abstract of doctoral dissertation

Predictive control of shunt active power filter using feedback from the supply current

The subject of the doctoral dissertation is the compensation of supply current harmonics, current unbalance and reactive power with the utilization of a shunt active power filter, which along with the coupling circuit constitutes a controlled current source. The main focus of this work is on the predictive control system with feedback from the supply current.

The objective of this dissertation has been the development and experimental verification of the shunt active power filter predictive feedback control which ensures a high compensation effectiveness and a relatively quick response to the load current changes. In view of that, the following thesis has been formulated: „A shunt active power filter with the predictive feedback control from the supply current provides a much higher compensation effectiveness of supply current distortion, unbalance and fundamental reactive power in the wide range of filter operating power, in comparison to a shunt active power filter with the feedforward control".

The dissertation presents theoretical issues related to both the electric power quality and the topic of active power filters. Moreover, a new precise predictive algorithm for the determination and control of the compensating current has been developed and implemented in the control system. In addition, an original concept of a control system combining the advantages of the closed-loop control system and open-loop control strategy in one algorithm has been proposed. The theoretical assumptions about the operation of the developed control algorithm have been verified in extensive simulation tests performed on the developed models. Furthermore, comprehensive experimental tests have been conducted with the use of a three-phase three-leg two-level voltage source inverter with the LCL circuit. These tests have taken into consideration the operation of the active filter in a stiff grid, weak grid and when powered by the diesel generator. Other determinants having an impact on the effectiveness of task realization performed by shunt active power filter and taken into account in the research include the value of power at which active filter operates, the non-linearities of the inverter, the value of non-linear load commutation reactors and delays resulting from the digital implementation of the control algorithm.

A significant achievement of this dissertation is the comprehensive stability analysis of the developed predictive closed-loop control system of shunt active power. The stability analysis constitutes an important issue in active current filtration, especially in the case of the closed-loop control system and the presence of an LCL coupling circuit since it imposes a resonance hazard. What is more, stability analysis may be utilized as a useful tool for designing the control system of an active power filter and selecting the values of its parameters.

Both experimental and simulation results presented in the work have shown that the closed-loop control is characterized by the high effectiveness of current distortion compensation, which is at a level unattainable in an open-loop control system. This has been observed in the wide range of power at which active power filter operated. This attribute has remained noticeable in the stiff grid conditions, weak grid conditions and in the case when the system was supplied from the diesel generator. As far as the fundamental reactive power is concerned, its compensation is more effective in the closed-loop control system than in the open-loop control strategy. The same inference has been drawn for the compensation effectiveness of the current unbalance. Moreover, the closed-loop strategy has demonstrated higher robustness to the incorrect inverter output voltage generation, caused by the non-linearities of the converter, than the open-loop control system. All these features indicate that it is possible to obtain higher compensation effectiveness from the same hardware with the utilization of the proposed predictive control system with feedback from the supply current.