RESEARCH INTO
DYNAMIC VOLTAGE REGULATION
AND RESTORATION TECHNOLOGY

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Research into Dynamic Voltage Regulation and Restoration Technology
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This thesis presents the findings of the research on dynamic voltage regulation and restoration control techniques for dimming control of electrical lighting systems and power quality control of power system. Both static and dynamic behaviors are given. The work studied and presented in this thesis includes the modeling, controller design, implementation, system analysis and experimental verification.

In Chapter 1, the general research background of this thesis, such as the existing issues and importance of power quality will be presented. The definitions and limitations of power quality will be reviewed. The basic concept of series connected inverters and Power Factor Corrector (PFC) will be discussed. Apart from the technical aspects of the converter systems, some surveys on stationary requirements that govern the design considerations will be given.

In Chapter 2, the apparatus and methods for providing dimming control of individual electrical lamps or more generally electrical lighting systems including systems formed by a plurality of individual lamps will be proposed. The invention relates in particular to a simple general purpose and non-intrusive dimming system that can be retro-fitted to existing lamps and which is non-intrusive in the sense that when not in use the dimming apparatus has no effect on the normal operation of the lamp. The patented dimming control technology is described in this chapter. The performance results of a case study of a large-scale installation of the dimmable road lighting system in Heshan City, China, will be presented.

In Chapter 3, the operation principles of the proposed fast dynamic response PFC controller will be described. The difference between the fast dynamics associated with the input current of power factor correctors (PFCs) and the slow dynamics associated
with their output voltage is typically exploited by using multiple control loops. The overall dynamic response is generally limited by the output voltage regulation loop. Research into an analogy-based controller for PFCs is at a slow pace. This chapter applies the concept of the boundary control method with a second-order switching surface for the boost type PFC, so as to achieve fast dynamic response. The method is based on predicting the state trajectory movement after a hypothesized switching action and the output can ideally be reverted to the steady state in two switching actions during the large-signal input voltage and output load disturbances. Theoretical predictions are verified with the experimental results of a 300W, 110V, 60Hz prototype.

In Chapter 4, it will present a fast dynamic control scheme for the capacitor-supported single-phase dynamic voltage restorer (DVR). The scheme consists of two main control loops as inner and outer control loops. The inner loop is used to dictate the gate signals for the switches in the DVR. It is based on the boundary control method with the second-order switching surface that is extended from the concept for PFC. The load voltage can ideally be reverted to the steady state in two switching actions during a supply voltage dip. The outer loop is used to generate the DVR output reference for the first loop. It has three control modes for achieving two different functions, including output regulation and output restoration. The first mode is for regulating the capacitor voltage on the dc side of the inverter, so that the output of the DVR is regulated at the nominal voltage. The second mode is for restoring the output with the near minimum energy injection by the DVR during a voltage dip. The third mode serves for the same purpose as the second mode. However, it will be activated when the capacitor voltage is reduced to a level that starts distorting the output voltage. The mode boundaries will be derived in this chapter. By studying the small-signal characteristics of the control loops, a set of design
procedures will be derived. A 500VA, 110V, 60Hz prototype has been built and tested with nonlinear loads. The dynamic behaviors of the prototype under different voltage dip depths will be investigated.

In Chapter 6, conclusions of the research and some suggestions for further studies will be given.
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