UNIVERSITI TEKNOLOGI MARA

ENHANCED ACTIVE DISTURBANCE REJECTION CONTROLLER IN THE UNIFIED POWER QUALITY CONDITIONER FOR POWER QUALITY AND STABILITY IMPROVEMENT

YU YUTING

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ABSTRACT

During national industrialization and urbanization, the power industry has advanced significantly. However, the extensive use of power electronic devices has led to a substantial increase in nonlinear loads in transmission, distribution, and power terminals. This has altered the current and voltage waveforms of the power grid, causing harmonic pollution and affecting its safe and stable operation. With the objective to promote complete power quality management theory and technology, this research focuses on the unified power quality conditioner (UPQC) in low-voltage distribution networks. In order to achieve novel outcomes, the research investigates important technologies such as detection, modulation, topology, modeling, and control. In order to analyze power flow and output voltage and current quality, it first looks at the UPQC structure and creates mathematical models for its series, shunt, and DC sides. Second, it examines the UPQC DC control module's voltage waveform when it is under PI control.The Active Disturbance Rejection Controller (ADRC) and super-twisting sliding mode controllers are intended to take the role of the DC module PI controller in order to lessen oscillation of the DC module output voltage.The compensation properties of UPQC under various controllers, as well as the oscillation of the intermediate DC voltage, are investigated and examined. Finally, this study offers a second- and third-order mixed generalized integrator (MSTOGI) that uses linear active disturbance rejection controller (LADRC) to efficiently reduce the detection delay for fundamental positive sequence components under non-ideal grid voltage settings.The MSTOGI-PLL based on LADRC achieves accurate phase locking under non-ideal grid conditions, ensuring unity power factor and improving waveform quality. Experimental results show that compared to PI-controlled MSTOGI-PLL and traditional Synchronous Reference Frame PLL (SRF-PLL), the LADRC-controlled MSTOGI-PLL significantly reduces the THD of load-side output current (47.5% lower than PI, 61% lower than SRF-PLL) and voltage (14.4% lower than PI, 83% lower than SRF-PLL).

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CHAPTER 1
INTRODUCTION

1.1 Research Background

In today's world, the foundation of economic growth is electricity. Modern power networks face numerous obstacles and challenges due to the ongoing development of new technologies, the ongoing advancement of information technology, and the growing prominence of energy and environmental concerns. Specifically, a great deal of contemporary power electronic equipment, including motor equipment with variable frequency speed regulation, high-performance computers, precision medical devices, and various smart home consumer electronics, have ever-higher demands for power quality in order to meet the demands of life and production. With the widespread use of distributed power sources and the ongoing improvement in the penetration rate of new energy sources like solar and wind power, the distribution network—an essential component of the power grid—has gained prominence.

The power market prioritizes the power quality requirements of power users, so a power quality problem is defined as: "Any power quality problem manifests itself as deviations in voltage, current, and frequency, resulting in damage to power user equipment or abnormal operation." The widespread employment of various nonlinear loads has led to an increase in the occurrence of power quality issues. To improve the efficiency of the power system, many power electronic devices have been used, such as high-efficiency variable frequency speed control systems, switching power supplies, and so on., in addition to large-capacity uncontrolled rectifier equipment. The use of these nonlinear loads has generated a substantial amount of unexpected current harmonics and voltage harmonics in the power system, thereby affecting the regular running of the load.

1.2 Motivation for This Work

This study focuses on UPQC inside a three-phase three-wire power system and seeks to enhance its compensatory capability during disturbances.