Operation of Unified Constant-frequency Integration Controlled Three-phase Active Power Filter in Unbalanced System

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Abstract—In recent years, the power quality of the AC system has become a great concern due to the rapidly increased numbers of electronic equipment. In order to reduce harmonic contamination in power lines and improve the transmission efficiency, active power filter research became a hot topic. Many control methods for the Active Power Filter (APF) were proposed. The theory and experiments have demonstrated that Unified Constant-frequency Integration (UCI) controller features excellent performance, simple circuitry, and low cost control methods for three-phase APF under three-phase balanced conditions. In this paper, a three-phase APF working in an unbalanced condition with a UCI controller are studied. Analysis and simulation show that with UCI control sinusoid input current can be realized, whether the input voltages are balanced or unbalanced.

I. INTRODUCTION

The power quality of the AC system has become a great concern due to the rapidly increased numbers of electronic equipment. In order to reduce harmonic contamination in the power lines, two basic methods are used: a) a rectifier with power factor correction (PFC) is used to prevent the generation of harmonic current; b) an active power filter (APF) is used to eliminate harmonic current generated by other equipment.

Most of the three-phase APFs employ a boost converter as their power stage. The main distinction between different APFs is their control strategy. In recent years, many control methods were proposed, most reported control approaches used in APF need to sense the load currents and calculate harmonic and reactive components then use it as current reference to provide compensation. Those methods require fast and real-time calculation, therefore, a high-speed digital microprocessor and high performance A/D converters are necessary, yielding high cost, low reliability, and high complexity. Article [1] introduced a promising solution named Unified Constant-frequency Integration (UCI) controller based on one-cycle control and mains current sensing for a three-phase APF. The theory and experiment have proved that the UCI controller is a high performance and low cost solution under three-phase balanced conditions. In this paper, the three-phase APF working in the unbalanced power system with UCI controller is studied. Analysis, simulation and experiments have shown that UCI controlled APF realizes sinusoidal input current in either balanced or unbalanced power systems.

II. THE DIFFERENCE BETWEEN BALANCED AND UNBALANCED THREE-PHASE SYSTEM

Fig.1 The vector diagram of three-phase input voltage in balanced and unbalanced power system. (a) Three-phase balanced; (b) Three-phase unbalanced; (c) Decoupled three-phase unbalanced vector into non-zero components and zero components.