Analysis and Design of New Switching Lookup Table for Virtual Flux Direct Power Control of Grid-Connected Three-Phase PWM AC–DC Converter

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***Abstract*—This paper proposes a comprehensive and systematic approach in developing a new switching lookup table for direct power control (DPC) based on grid virtual flux estimation, implemented in a grid-connected three-phase ac-to-dc converter. The approach provides detailed information regarding the effects of a particular converter voltage space vector to the instantaneous input active and reactive power distributions in the converter system. Thus, the optimal converter switching states are able to be selected by the switching table, allowing the smooth control of the active and the reactive power for each sector. The usage of input ac voltage sensors for synchronization and input power calculation is avoided by applying a virtual flux concept in the control scheme. The grid virtual flux estimation technique is used to extract the grid voltage information from the converter switching states, line currents, and dc-link output voltage. Detailed explanation and analysis regarding the development of virtual flux DPC utilizing the proposed switching lookup table is given in this paper. Finally, the steady-state as well as dynamic performances of the proposed controller is tested both in simulations and laboratory experiments. There exist close agreements between the simulation and experimental results.**

***Index Terms*—AC–DC converter, hysteresis controller, instantaneous active and reactive powers, power factor (pf) correction, switching lookup table, virtual flux direct power control (DPC) (VFDPC).**

I. INTRODUCTION

THE INCREASING usage of power diode and thyristor rectifiers for ac-to-dc conversion is becoming a problem in transmission and distribution lines due to the harmonic and reactive currents that they inject into the system. The nonsinusoidal shape of the input current drawn by the conventional ac–dc converter (rectifier) generates significant harmonic components which will result in increasing the volt–ampere rating of the utility equipment such as generators, transmission lines, and transformers. International technical organizations and government agencies have introduced standards and regulations such as IEEE 519 and IEC 61000 to maintain the voltage and current quality of utility grids at accepted levels [1]. Therefore, front-end three-phase bidirectional ac–dc converters are becoming more and more attractive in utility-interfaced applications such as high-performance adjustable speed drives due to the numerous advantages. They provide low harmonic content in line currents which leads to the achievement of almost sinusoidal input currents, controllable power factor (pf) and dc-link voltage, regeneration capability, and excellent steady-state and dynamic performances. The converter must be controlled properly in order to achieve proper power flow regulation in the power conversion system. Various control strategies have been proposed in recent years on the ac–dc converter. The control strategies include the phase and amplitude control [2], hysteresis current control, voltage-oriented control [3], predictive control [4], and direct power control (DPC) [5], [6] methods.

In general, the conventional control techniques of an ac–dc converter require three types of sensors such as three current sensors to measure three-phase input currents, three voltage sensors to measure three-phase input voltages, and a dc voltage sensor to measure the dc-link output voltage. Using all of these sensors will cause the system to be bulky and expensive. In addition, the sensing signal is usually subject to high frequency noise and interference. Any incidental misreading of a signal caused by a failed sensor may decrease the system reliability and performance. Therefore, it is desirable to reduce the number of sensors to the minimum possible.

In [7], the authors eliminate the employment of ac input voltage sensors by estimating the three-phase grid voltage through the computation of the time derivative of measured currents. The authors combined the input voltage source estimation method with the DPC strategy to operate the three-phase ac–dc converter. The basic idea of DPC is a direct control of active and reactive powers without any internal current control loop

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