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Research of the Single-Switch Active Power Factor Correction for the Electric Vehicle Charging System

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Abstract

Face to energy crisis and increasingly severe pressure on environmental pollution, electric vehicles have become the new direction of the vehicles. In order to meet the electric vehicle's charging requirements for high power factor (PF), this paper intends to implement single-switch active power factor correction (APFC) function under the control of voltage, current dual closed-loop in Inductor current "continuous conduction mode" (CCM). The article uses saber software to simulate with the single-phase and three-phase PFC system and finally develops a 3KW experiment prototype. The results of the power experiment validate the feasibility of the method. The power factor can be improved to nearly 1 and it has good application value in actual project.

Keywords: APFC; CCM; electric vehicle charging system; single-switch

1. Introduction

With the continuous depletion of fossil fuels and increasingly serious environmental pollution, new energy has become a hot direction of the research. Electric vehicle as a non—polluting transportation tool，will have great advantages in the market.

The traditional electric vehicle charging system uses diode rectifier bridges topology cascade with DC-DC and has the following disadvantages: the input current harmonic content is high and absorbs reactive power from the grid. Hence the input power factor is very low.

To solve the above problems, a kind of power factor correction circuit is necessary to improve the PF and reduce the current harmonic content. This paper intends to implement single-switch active power factor correction function with the method of voltage, current dual closed-loop control of boost converter with average current control.

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The simulation and experiment show that the single-switch PFC can meet the requirements of high PF and low THD and it will be used as the former-class of 3KW charger on electric vehicle.

2. Single-switch PFC Circuit and CCM control strategy

The following Fig.1 is the main circuit of single-phase single-switch PFC, which is composed of diode rectifier bridges, inductance, MOSFET, capacitor and the resistance load. The circuit is a boost converter, so it has two operating mode: switch conducting and switch non- conducting mode. When the switch conducting, the power supply charges the inductance, and the capacitor discharges through the resistance; when the switch non-conducting, the power supply charges the capacitor and resistance through the diode with a voltage higher than the supply and the voltage of the resistance increases. The advantages of the circuit are as follows: the input current can be continuous and modulated in the whole sinusoidal voltage cycle, so the PF can be high. Besides, the drive circuit is simple and the peak current of MOSFET is low.

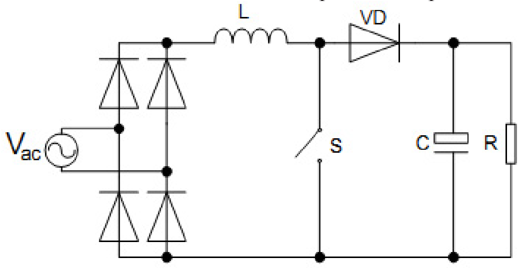

Fig. 1. the main circuit of single-phase single-switch PFC

The Fig.2 is the main circuit of three-phase single-switch PFC. When the input three-phase voltage is balanced, the principle of three-phase PFC circuit is similar with single-phase PFC circuit.

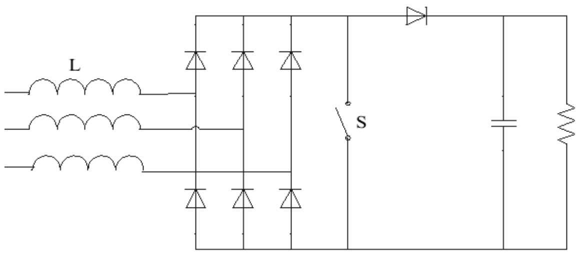

Fig. 2. the main circuit of three-phase single-switch PFC

Essentially PFC circuit is an AC/DC converter. The standard converter uses pulse width modulation (PWM) techniques to adjust the input power to provide appropriate power for the load. The structure of dual closed-loop control is as Fig.3. The sampling output voltage is compared with a reference voltage, then after a PID correction the difference will be the output of voltage. This error signal is used to alter the pulse width working together with the current loop. The voltage loop makes the output voltage more stable. If the output voltage is higher, the pulse width decreases, thereby making the output voltage lower, so that the output voltage is restored to the normal output value. This is the principle of the voltage loop.