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Single-Phase Bridgeless Zeta PFC Converter with Reduced Conduction Losses

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Abstract

This paper presents a new single phase front-end ac–dc bridgeless power factor correction (PFC) rectifier topology. The proposed converter achieves a high efficiency over a wide range of input and output voltages, a high power factor, low line current harmonics and both step up and step down voltage conversions. This topology is based on a non-inverting buck-boost (Zeta) converter. In this approach, the input diode bridge is removed and a maximum of one diode conducts in a complete switching period. This reduces the conduction losses and the thermal stresses on the switches when compare to existing PFC topologies. Inherent power factor correction is achieved by operating the converter in the discontinuous conduction mode (DCM) which leads to a simplified control circuit. The characteristics of the proposed design, principles of operation, steady state operation analysis, and control structure are described in this paper. An experimental prototype has been built to demonstrate the feasibility of the new converter. Simulation and experimental results are provided to verify the improved power quality at the AC mains and the lower conduction losses of the converter.

Key words: AC-DC converter, Bridgeless rectifier, Conduction losses, Power factor correction, Zeta converter

I. Introduction

In recent years, single phase ac-dc PFC converters have received much attention due to the dramatic growth in the use of electronic equipment and these ac-dc converters introduce harmonic currents. These harmonic currents cause a lower power factor at the ac mains, voltage distortion and noise [1]-[3]. To comply with harmonic standards and to increase transmission efficiency in power systems, PFC techniques are necessary in ac-dc power converters [4], [5]. In addition, electronic equipment benefits from power converters with high efficiency over a wide range of input and output voltages [6]. However, conventional ac-dc converter designs cannot deliver high efficiency over a wide operation range in both step up and step down voltage conversions and it is difficult to design the control system. Therefore, a new topology design that improves efficiency and reduces the complexity of the control is desirable. In this paper, a novel bridgeless PFC rectifier topology is proposed to achieve these objectives.

The most common PFC converter architecture in the market consists of a front-end diode bridge rectifier circuit where the bridge rectifier is followed by a boost dc-dc converter. The boost converter is popular in PFC converter architecture due to its simple circuit, simple control scheme and low input current harmonics [7]-[13]. However, this architecture is not suitable for high power applications because of the high conduction losses caused by the input diode bridge. In addition, three semiconductors exist in the current flowing path in a complete switching period. Furthermore, one significant drawback of the boost converter which is used in the architecture is that the output voltage of the boost converter is always higher than the input voltage. Besides, the converter does not have the capability to protect against short circuits or load overcurrent [14].

Unlike boost converter, Cuk and SEPIC converters can be operated as a voltage step up or step down converter. However, these converters are not able to protect against the startup inrush current condition. Therefore, an additional circuit is necessary to protect against inrush current [4], [14].

To avoid the rectifier input bridge, a number of bridgeless PFC converter topologies have been proposed by numerous

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