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HIGH POWER FACTOR AC-DC CONVERTER WITHOUT PFC PREREGULATOR

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Abstract: AC-DC converters are widely used in many industrial applications for electrical power conversion such as for telecom equipment, electric vehicles, information technology equipment, power systems and space power systems power systems based on renewable energy resources. Conventional AC-DC converters generally have two conversion stages, an AC-DC stage that operates with some sort of power factor correction to ensure good power quality at the input, and a DC-DC conversion stage that takes the DC output of the AC-DC converter and converts it to the desired output DC voltage. Due to the cost of having two separate and independent converters, this paper reviews the different type of converters based on their construction, design and proposes a single power conversion ac-dc converter with high power factor and high efficiency. To obtain a high power factor without a power factor correction circuit, this paper proposes a novel control algorithm.

Keywords: AC-DC Converter, DC-DC Boost Converter, Single Power Conversion

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INTRODUCTION

The ac–dc converter consists of a full-bridge diode rectifier, a dc-link capacitor and a high frequency dc–dc converter. These converters absorb energy from the ac line only when the rectified line voltage is higher than the dc- link voltage. Therefore, these kinds of converters have a highly distorted input current, resulting in a large amount of harmonics and a low power factor. To solve the problem of harmonic pollution caused by ac–dc converters, a number of power factor correction (PFC) ac–dc converters have been proposed and developed [1].

The PFC ac–dc converter can be implemented by using two power-processing stages. The PFC input stage is used to obtain high power factor along with a constant dc-link voltage. Most PFC circuits employ the boost converter [2].

The output stage, which is a high frequency dc–dc converter, gives a desired output. Two power-processing stages require each control circuit consisting of gate drivers and those controllers. In general, the PFC ac–dc converter can be categorized into two types: two-stage ac–dc converters [3] and single stage ac–dc converters [4].

Two-stage ac–dc converters consist of two power-processing stages with their respective control circuits. However, two-stage ac–dc converters raise power losses and the manufacturing cost, eventually reducing the system efficiency and the price competitiveness. In efforts to reduce the component count, the size, and the cost, a number of single-stage ac–dc converters have been proposed and developed. The main idea is that a PFC input stage and a high frequency dc–dc converter are simplified by sharing common switches so that the PFC controller, the PFC switch, and its gate driver can be eliminated. Most single-stage ac–dc converters in low-power application employ single-switch dc–dc converters such as flyback or forward converters [5].

These converters are simple and cost-effective. However, they have high switching power losses because of the hard-switching operation of the power switch. Thus, to overcome the drawback, single stage ac–dc converters based on the asymmetrical pulse width modulation (APWM) half-bridge converter have been proposed [6].

They have low switching losses because of the zero-voltage switching (ZVS) operation of the power switches. However; the conventional single-stage ac–dc converters have high voltage stresses or a low power factor in comparison with the two-stage ac–dc converter. Also, the PFC circuit used in the single-stage ac–dc converter requires the dc-link electrolytic capacitor and the inductor. The dc-link electrolytic capacitor and the inductor raise the size and the cost of the converter. To solve these problems, the dc-link electrolytic capacitor should be removed from the circuits. The approach of achieving this is through the alleviation of the pulsating component of the input power by sacrificing the input power factor [7].

The main idea is to intentionally distort the input current such that there is little low-frequency power-ripple component being generated at the input. Consequently, non-electrolytic capacitors such as film capacitors or ceramic capacitors can be used instead of electrolytic capacitors. This approach is mostly applied to single-switch PFC ac–dc converters. Compared to the conventional single-stage ac–dc converters with the dc-link electrolytic capacitor, the converters using this approach are small and cost-effective; on the other hand, they have drawbacks such as low power factor and low efficiency because of the discontinuous current mode (DCM) operation and the hard-switching operation. Therefore, these converters are attractive in low-cost and low-power application such as a light-emitting diode (LED) power supply.

BLOCK DAIGRAM

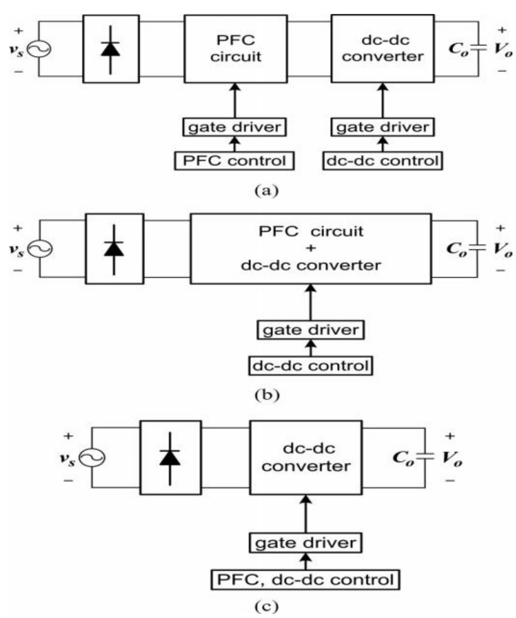

Fig.1 Block Diagrams of conventional PFC converters and the proposed converters (a) Two stage converter (b) single stage converter (c) Single power conversion converter

The objective of this paper is to propose the single power-conversion ac–dc converter with the high power factor and the high power efficiency. The proposed converter consists of a full-bridge diode rectifier and a series-resonant active-clamp dc–dc converter. This converter provides a simple structure, a low cost, and low voltage stresses because it has only high frequency dc–dc converter. To obtain high power factor without a PFC stage, a novel control algorithm is proposed. The proposed converter provides high power factor and single power-conversion by using the novel control algorithm instead of the PFC circuit. Also, the active-clamp circuit clamps the surge voltage of switches and recycles the energy stored in the leakage inductance of the transformer.

OPERATION PRINCIPLE OF THE AC–DC CONVERTER

Concept of the Single Power-Conversion AC–DC Converter Fig. 1(a) shows the schematic diagram of the conventional two-stage ac–dc converter. It comprises a full-bridge diode rectifier, a PFC circuit, a control circuit for the PFC circuit, a high frequency dc–dc converter, and a control circuit for output control. The control circuit is composed of gate-drivers and a power processing stages with their respective control circuits. Also, the boost type PFC converter used in most PFC input stages requires the dc-link electrolytic capacitor and the inductor. Two control circuits, the dc-link capacitor and the inductor raise the size, weight and the cost of the converter and reduce the price competitiveness. On the other hand, the advantage is to decouple control of the dc-link capacitor voltage from that of the output voltage and realize much tighter output control. Therefore, two stage ac–dc converters are preferred option when reliability is more important concerns than cost per unit.

Fig. 1(b) shows the schematic diagram of the conventional single-stage ac–dc converter. It comprises a full-bridge diode rectifier, a PFC circuit, a high frequency dc–dc converter, and a control circuit for output control. The PFC circuit and the high frequency dc–dc converter are simplified by sharing common switches for eliminating the PFC switch and the control circuit for the PFC circuit as shown in Fig. 1(b).single-stage ac–dc converters have only one control circuit. Thus, the output voltage is easily regulated by a controller and the power factor is strongly influenced by the design of the PFC circuit. However, single-stage ac–dc converters have several disadvantages. First, the power factor is also related to the controller, indicating that the variation of the load or the input voltage will change the power factor. Second, the output voltage control bandwidth is limited to a few hertz not to excessively distort the input current. Third, single-stage ac–dc converters require the dc-link electrolytic capacitor and the inductor for the PFC circuit, just like two-stage converters. Finally, the conventional single-stage ac–dc converters have high voltage stresses or low power factor in comparison with two stage ac–dc converters.

Fig. 1(c) shows the schematic diagram of the single power-conversion ac–dc converter. It consists of a full-bridge diode rectifier, a high frequency dc–dc converter, and a control circuit. That is, the single power-conversion ac–dc converter has also one control circuit because it has no PFC circuit. However, it requires the control algorithm for both PFC and output control, unlike single-stage ac–dc converters. Also, it has a large ac second-harmonic ripple component reflected at the output voltage in comparison with two-stage and single stage converters because it has no dc-link electrolytic capacitor. However, the single power-conversion ac–dc converter provides a simple structure, a low cost, and low voltage stresses because it has no PFC circuit composed of the inductor, power switching devices and the dc-link electrolytic capacitor. Therefore, the single power-conversion ac–dc converter is preferred option when the cost per unit is more important concerns than reliability.

CONTROL ALGORITHM

The converter proposed in this paper does not contain PFC circuit. Therefore, for obtaining a high power factor, it requires the control algorithm for both PFC and output control. The duty ratio D of the dc-dc boost converter according to the input current is hard to control because the relation of D and input current is nonlinear. To achieve good controllability, the nonlinear system needs to be transformed into the linear system by the feedback linearization.

CONCLUSION

This paper reviews some influence papers in the design of ac-dc converter. This converter converts the continues ac supply in to constant dc supply with providing high power factor. Some AC-DC converter consists of full bridge diode rectifier and DC-DC boost converter with PFC Circuits. The PFC ac-dc converter classified in two types that is two stage ac-dc converter and single stage ac-dc converter. Two-stage ac–dc converters consist of two power-processing stages with their respective control circuits while in single stage ac-dc converter the PFC input stage and a high frequency dc–dc converter are simplified by sharing common switches .This converters are simple and cost effective but they have high switching losses. This paper proposes a single power conversion ac-dc converter with high power factor and high efficiency. Control algorithm used in this converter can be used to the boost type PFC ac-dc converter. Since it is based on the control algorithm of the PFC boost converter in the continuous conduction mode.

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