Power Factor Correction In A Soft Switching Bridgeless Ac Dc Converter

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Abstract

Novel soft-switching, bridgeless power factor correction (PFC) boost converter is proposed for power supply and battery charging applications. And its converter operates in both pulse-width-modulation (PWM) mode and resonant mode each switching cycle, and utilizes paradigm average current mode control. The converter is bridgeless, so eliminating the need for a front-end diode bridge rectifier. It operates in continuous conduction mode (CCM) and achieves zero voltage switching (ZVS) for all switches. The proposed converter also reduces the turn-off losses of the PWM switches, therefore nearly eliminating switching losses. The PWM switches of the proposed converter can be driven with the same PWM signal, enabling simplified control.

Key Words: AC-DC converters, battery chargers, PFC, power supplies, resonant converters, soft-switching, ZCS, ZVS.

1 Introduction

FOR electricity components and battery chargers rated above approximately three hundred W, a the front-stop increase kind strength
issue correction (%) ac-dc converter is used to conform with regulatory requirements for enter contemporary harmonics. currently, the California strength commission (CEC) has additionally set tough efficiency requirements for battery chargers to lessen electricity losses [1]. furthermore, excessive frequency operation providing high electricity density is proper for all power converters. however, high switching frequency operation of an ac-dc converter increases switching losses, resulting in decreased converter performance. hence, it is acceptable to have soft switching operation at high switching frequency operation (e.g. normally above one hundred kHz). % converters can function in discontinuous conduction mode (DCM) [2]-[3], boundary conduction mode (BCM) [4][5], or non-stop conduction mode (CCM) [6]. Lately, triangular conduction mode operation has additionally been proposed [7]. But, CCM operation has decrease conduction losses. The increase converter running in CCM following a diode bridge rectifier is most widely used as the ac-dc converter for %. This converter is very simple and nearly cohesion electricity component may be finished with proper manage techniques. The disadvantage of this converter is excessive switching losses inside the increase transfer and excessive conduction losses inside the diode bridge. in addition, it could be tough to manage the heat within the enter rectifier diode bridge. In high frequency operation, switching losses further reduce the efficiency and the enhance diode opposite recovery price introduces diode turn-off losses. so as to lessen the switching losses within the increase converter, many soft-switching techniques have been proposed in particular for percent circuits, such as [8] and [9]. but, with those circuits, due to the diode bridge rectifier, the conduction loss problem stays. not like the boost % converter, there’s no diode bridge rectifier in the dual raise/bridgeless enhance converter topology [10]-[12]. This topology reduces the whole semiconductor count number from six to 4 and reduces conduction losses and the associated warmth control problem within the enter rectifier bridge. however, the twin raise converter has high switching losses because of difficult-switching operation of the PWM switches. To reduce the switching losses of this converter, gentle-switching topologies had been proposed [14]-[17]. However, the topology proposed in [14] and [16] reduces turn-off losses best and the auxiliary circuit of the proposed converter in [15] and [17] is complex. in the semi-bridgeless converter, since the
go back course inductance conducts best a small part of the entire return current, the total converter inductance is twice that of the traditional improve percent converter [18]-[20]. The H-bridge converter proposed in [21] calls for 3 remoted cutting-edge sensors, increasing complexity. The totem-pole converter does now not want % inductors because the semi-bridgeless converter does [22]. but, the totempole converter makes use of the MOSFET body diode to carry the weight modern, creating a opposite restoration trouble, which makes it detrimental to use in CCM operation [13]. To reduce the opposite-recuperation losses of the frame diode, the topologies in [3]-[6] have been proposed. but, in those circuits, it’s miles essential to feel the tremendous and bad line-cycle operation to correctly manipulate the PWM switches, therefore the control and sensing is really complicated. As an answer, the totem-pole converter proposed in [7] may be pushed with the equal PWM indicators for each PWM switches. The drawback of this converter is the improved wide variety of passive factors. The converter proposed in [28] realizes excessive utilization of the electricity semiconductors even as lowering the improve inductor length and line clear out necessities. The drawback of this converter is the high wide variety of semiconductors. To lessen conduction loss, versions of the bridgeless p.c topologies based at the Cuk and SEPIC converters were proposed [9]-[6]. the second inductor used in the Cuk and SEPIC converters is distinctly massive in length, which reduces energy density. moreover, the topologies proposed in [9], [2], [4] and [6] have an improved range of passive elements, which provides value and reduces strength density. The dcdc converter proposed in [7] can recognize ZVS for each switches, and has galvanic isolation. For ac-dc conversion, this converter calls for a diode bridge rectifier, increasing conduction losses. The ac-dc increase converter topology proposed in [38] realizes bridgeless converter operation to reduce conduction losses. The disadvantage of this converter is the undesirable voltage spike throughout the PWM switches, limiting its use for high frequency and high power programs. moreover, this converter calls for complicated variable frequency virtual manipulate, and the PWM switches are difficult-switched. The topology proposed in [3] operates in DCM, and is fine appropriate for low electricity applications (i.e. beneath 300 W). on this paper, a new ZVS hybrid resonant pulse-width modulated (HRPWM) ac-dc % converter is proposed.
in contrast to the traditional raise or bridgeless improve converters, the proposed converter minimizes switching losses by using achieving ZVS for all switches. furthermore, present day switching (ZCS) for the output rectifier diodes reduces the reverse-recovery losses. The proposed converter additionally realizes bridgeless converter operation which minimizes the warmth control troubles in diode bridge rectifier. in contrast to the totem-pole converter, the proposed converter can be driven with the equal PWM sign and it doesn’t require sensing each the advantageous and negative AC line cycle operation, enabling simplified manage. The resonant components used within the proposed converter are especially small in size as compared with the dimensions of the passive elements in the Cuk and SEPIC converters. The proposed converter can operate at high switching frequency without any undesirable voltage spike throughout the PWM switches in contrast to the resonant topology proposed in. The converter operating concepts are supplied in segment II and the modes of operation are supplied in section III. The converter analysis and a design instance are given in section IV. Experimental consequences are provided.

2 PROPOSED CONVERTER OPERATING PRINCIPLES

The proposed ZVS HRPWM ac–dc p.c converter is illustrated in Fig. 1. This converter is bridgeless and has most effective one enter inductor Lin. The % switches S1 and S2 may be pushed with the same PWM signal, consequently it isn’t always essential to experience each the superb and poor ac line-cycle operation. The converter operates in the resonant mode whilst S1 and S2 are on, using resonance among capacitance Cr, and inductance Lr, and PWM mode when S1 and S2 are off and the auxiliary transfer Sa is on, consequently its operation may be defined as hybrid resonant PWM. The resonant frequency of the HRPWM converter has a widespread effect at the operation of the converter.
The resonant frequency may be better, lower or identical to the switching frequency. Consequently, there may be 3 viable resonant modes of operation whilst the PWM switches (S1 and S2) are on, which can be defined in the sub-sections that comply with.

3 RESONANT FREQUENCY OPERATION

The condition for at resonant frequency operation, where the resonant frequency is equal to the switching frequency, is given by (1), where the resonant period \( T_r \) of the resonant tank \( L_r-C_r \) is defined by (2).

With resonant frequency operation, D2 turns off at zero contemporary, allowing the turn-off modern of S1 to be low, consequently lowering the flip-off switching losses in S1. However, considering in an ac-dc converter the responsibility cycle \( D \) varies notably, the converter would want to operate with a variable switching frequency.
in an effort to hold a regular on-time c programming language for operation at resonance. This would increase the converter layout complexity.

4 CONCLUSION

A new zero voltage switching (ZVS), hybrid resonant pulsewidth-modulated (HRPWM) bridgeless ac-dc raise converter topology has been offered in this paper for application in strength components and battery chargers. The proposed converter reduces switching losses by way of knowing ZVS for the 2 % MOSFETs and one auxiliary MOSFET. The output diodes operate with controlled di/dt flip-off, minimizing opposite restoration losses. The proposed converter has many blessings for realistic implementation. This converter can be without problems implemented with popular average current mode control and the PWM switches may be pushed with the same PWM sign, so extra circuitry isn’t required to feel the
positive, or negative line-cycle operation. Moreover, the bridgeless operation eliminates the hassle with heat control in a conventional diode rectifier preceding a lift percent converter. The ZVS HRPWM converter operation and analysis have been supplied. An experimental prototype changed into been constructed to verify the proof-of-concept and the important thing experimental waveforms had been provided. The converter strength thing and performance measurements were provided as a function of load strength at 100 V and 240 V input. The strength element is greater than 0.ninety eight from 1/2 load to full load. The proposed converter achieves a height performance of 96.ninety five% at 240 V enter and 650 W output energy. In comparison to the conventional hard-switched p.c raise converter on the most loss working factor (full load and 100 V ac input), the proposed converter achieves 1 percent point performance development and operates with decrease semiconductor device temperatures.

References


