ISSN: 2581-3404 (Online)
International Journal of Innovative Research in Technology and Management (IJIRTM), Volume-3, Issue-6, 2019

Literature Survey on Single Stage Zero Voltage Switching Converter with Boost Type Active Clamp

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ABSTRACT
An ac to dc converter is an integral part of any power supply unit used in electronic equipment which forms a major part of load on the utility. Generally, to convert line frequency ac to dc, a line frequency diode bridge rectifier is used. The ripple in the dc output voltage is reduced by a large capacitor used at the rectifier output, which makes the current rich in low order harmonics and the input power factor poor. Because of the problems associated with low power factor and harmonics. Power factor correction schemes have been implemented mainly for heavy industrial loads like induction motors, induction heating furnaces etc., which forms a major part of lagging power factor load. Hence, power factor correction is becoming an important aspect even for low power application electronic equipments. There are two types of PFC's. 1 Passive PFC, 2 Active PFC. Any DC-DC converters can be used for power factor correction, if a suitable control method is used to shape its input current or if it has inherent PFC properties. The DC-DC converters can operate in Continuous Inductor Current Mode – CICM or Discontinuous Inductor Current Mode - DICM. In CICM, different control techniques are used to control the inductor current. Some of them are Peak current control , Average current control, Hysteresis control, Borderline control Power electronics is the technology associated with efficient conversion, control and conditioning of electric power by static means from its available input form into the desired electrical output form. The goal of power electronics is to control the flow of energy from an electrical source to an electrical load with high efficiency, high availability, and high reliability using small size, light weight and low cost devices.

Keywords:- Generation, distribution, AC, DC, Current.

GENERAL INTRODUCTION

In recent years, there has been growing interest in power electronics systems one reason for this is the increasing utilization of electrical and electronics equipment, not only for industrial, but also for commercial and residential applications. Another reason is interest in improving the system efficiency, besides the expansion of the application of renewable energies. This growing demand has favored the development of new power electronics devices, as well as novel power converter topologies, some of the areas where power electronics used:

1. GENERATION (Thermal, hydro, Nuclear, wind, solar and other)
2. INDUSTRIAL
3. DOMESTIC
4. TRANSPORT

Power electronics application broadly includes converters', inverters, choppers etc. The AC to DC converter (rectifier) is one of the most popular

power electronics devices which are an efficient and convenient source of DC power.
A great portion of electrical and electronic devices currently in use is designed to operate using direct current (DC) power while, for reasons of distribution efficiency, most power is ultimately delivered to such devices as alternating current (AC) power. Therefore, the AC-DC front-end converter is needed to converter the AC power to the DC power in many electrical and electronic devices. Two-stage approach is widely used in the AC-DC front-end converters for high power application. Because of its continuous input current and simplicity, Continuous Conduction Mode (CCM) boost topology is the most popular for the power factor correction (PFC) stage.

II LITERATURE REVIEW

Power Electronics has already found an important place in modern technology and has revolutionized control of power and energy. As the voltage and current ratings and switching characteristics of power semiconductor devices keep improving, the range of applications continues to expand in areas such as lamp controls, power supplies to motion control, factory automation, transportation, energy storage, multi megawatt industrial drives, and electric power transmission and distribution.

The greater efficiency and tighter control features of power electronics are becoming attractive for applications in motion control by replacing the earlier electro-mechanical and electronic systems. Applications in power transmission include high-voltage dc (VHDC) converter stations, flexible ac transmission system (FACTS), and static-var compensators. In power distribution these include DC to AC conversion, dynamic filters, frequency conversion, and Custom Power System.

Process control and energy conservation are the two primary reasons for using an adjustable speed drive. However, voltage sags are the most important power quality problems facing many commercial and industrial customers. S. S. Deswal, et al. [1] proposed a converter that provided ride through capability during sag and swell. Further, input currents are near sinusoidal eliminating the need of braking resistor.

Swapnil Arya et al. [2] presented design and simulation of a boost converter for power factor correction. This also covers the important specifications of boost power circuit design and the IC UC3854A, which regulates the boost converter for an input voltage range of 200 – 270Volts with the output voltage controlled at 450 volts.

Chongming Qiao et al. [3] performed a topological review of the single stage power factor corrected (PFC) rectifiers presented. Most of reported single-stage PFC rectifiers cascade a boost type converter with a forward or a fly back dc-dc converter so that input current shaping, isolation, and fast output voltage regulation are performed in one single stage. For the cascade connected single-stage PFC rectifiers, the energy storage capacitor is found in either series or parallel path of energy flow. It is found that many of these topologies can be implemented by combining a 2-terminal or 3terminal boost ICs cell with dc-dc converter along with an energy storage capacitor in between.

Yungtaek Jang et al. [4] described implementation of a novel high-power-factor (HPF) boost converter with active snubber. The snubber circuit reduces the reverse-recovery-related losses of the rectifier and also provides zero-voltage switching for the boost switch and zero-current switching for the auxiliary switch. The performance of the proposed approach was evaluated on an 80-kHz, 1.5-kW, universal-line range, HPF boost converter. The proposed technique improves efficiency by approximately 2% at full load.

Fariborz Musavi, et al. [5] experimentally studied a phase shifted semi-bridgeless boost power factor corrected converter is proposed for plug in hybrid electric vehicle battery chargers. The converter features high efficiency at light loads and low lines, which is critical to minimize the charger size, charging time and the amount and cost of electricity drawn from the utility the component

ISSN: 2581-3404 (Online)
International Journal of Innovative Research in Technology and Management (IJIRTM), Volume-3, Issue-6, 2019

count, which reduces the charger cost and reduced EMI. The converter is ideally suited for automotive level I residential charging applications. A detailed converter description and steady state operation analysis of this converter is presented. Experimental results of a prototype boost converter, converting universal AC input voltage to 400 V DC at 3.4 kW are given and the results are compared to an interleaved boost converter to verify the proof of concept, and analytical work reported. The results show a power factor greater than 0.99 from 750 W to 3.4 kW, THD less than 5% from half load to full load and a peak efficiency of 98.6 % at 240 V input and 1000 W load.

Octavian Dranga et al. [6] investigated the bifurcation behavior of the power-factor-correction (PFC) boost converter under a conventional peak current-mode control. The converter is operated in continuous-conduction mode. The bifurcation analysis performed by computer simulations reveals interesting effects of variation of some chosen parameters on the stability of the converter. The results are illustrated by time-domain waveforms, discrete-time maps and parameter plots. An analytical investigation confirms the results obtained by computer simulations. Such an analysis allows convenient prediction of stability boundaries and facilitates the selection of parameter values to guarantee stable operation.

Gui-Jia Su et al. [7] inferred that a Half-bridge inverter is very suitable for single phase on-line UPS applications. These include fewer active switches, a common neutral connection – not requiring an isolation transformer, and sinusoidal input currents if a power factor correction (PFC) converter is used at the front end. This paper presents a comparative study of PFC converters for single-phase half-bridge UPS inverters. A traditional half-bridge converter and two recently introduced ac-dc/dc-dc boost converters are comparatively investigated for active switch count, voltage stresses on the switches, and capability of voltage balance control of the dc bus capacitors.

Lon-Kou Chang et al. [8] presented a novel simple forward ac/dc converter with harmonic current correction and fast output voltage regulation. In the proposed ac/dc converter, a transformer incorporate ingreset winding provides two main advantages. First, the bulk inductor used in the conventional boost-based power-factor-correction cell is omitted in the proposed converter, allowing significant volume and weight of magnetic material to be saved. Second, the voltage across the bulk capacitor can be held under 450 V by adjusting the transformer winding ratio, despite the converter operating in a wide range of input voltages (90 265 V/ac). This new converter complies with IEC 61000-3-2 under a load range of 200 W and has fast output voltage regulation.

Sangsun Kim et al. [9] introduced a new parallel-connected single phase power factor correction (PFC) topology using two fly back converters is proposed to improve the output voltage regulation with simultaneous input power factor correction and control. This approach offers lower cost and higher efficiency by parallel processing of the total power. Fly back converter-I primarily regulates output voltage with fast dynamic response and processes 55% of the power. Fly back converter-II with ac/dc PFC stage regulates input current shaping and PFC, and processes the remaining 45% of the power. This paper presents a design example and circuit analysis for 200 W power supply. A parallel-connected interleaved structure offers smaller passive components, fewer losses even in continuous conduction inductor current mode, and reduced volt-ampere rating of dc/dc stage converter. TI-DSP, TMS320LF2407, is used for implementation. Simulation and experimental results show the performance improvement.

Oscar García et al. [10] made new recommendations for future standards as power factor correction circuits have become an urge in present day scenario. In the recent years, a great number of circuits have been proposed with non sinusoidal line current. In this paper, a review of the most interesting solutions for single phase and low power applications is carried out. They are classified attending to the line current waveform, energy processing, number of switches, control loops, etc. The major advantages and disadvantages are highlighted and the field of application is found.

Woo-Young Choi et al. [11].Which can simultaneously perform input power factor correction and dc–dc conversion, using conventional phase-shift PWM and can maintain a primary-side dc bus voltage of less than 450 V even at a high input line voltage of 265 Vrms. The proposed converter has these features due to the novel implementation of an asymmetrical auxiliary transformer winding that is placed in series with the input inductor and acts as a boost switch. The operation of the proposed converter is explained in detail, and a detailed design procedure is given and demonstrated with an example.

Yao-Ching Hsieh et al. [12] proposes an interleaved flyback converter, which is remarked with zero-voltage-switched active switches and reduced reverse-recovery loss on the rectifying diodes. The converter is composed of two parallel-operated identical fly back converters and an auxiliary inductor shunted between the diodes. This converter can provide up to 500Wpower with highest efficiency as high as 91%. In addition, burst-mode control is equipped to drive the converter at low load. Even at 50-W output, the efficiency is higher than 83%.

A two stage PFC boost-forward converter, was compared with the fly-back converter by Amir Hossein Ranjbar et al. [13], as a single stage PFC, from reliability point of view. Based on measurement results, the reliability of the single-stage and two stage PFCs have been calculated. It is shown that the single stage PFC has a higher reliability than the latter. The inclusion of a few additional diodes and passive elements in the high-frequency full-bridge ac–dc converter with galvanic isolation permits one to achieve sinusoidal input-current wave shaping and output-voltage regulation simultaneously without adding any auxiliary transistors. Recently, this procedure, together with an appropriate control process, has been used by Hugo Santos Ribeiro and Beatriz Vieira Borges et al. [14] to obtain low-cost high-efficiency single-stage converters. In an attempt to improve the performance of such converters, this paper introduces three new single-stage full-bridge ac–dc topologies with some optimized characteristics and compares them with the ones of the existing full-bridge single-stage topologies. The approach used consists in the definition of the operating principles identifying the boost function for each topology, their operating limits, and the dependence between the two involved conversion processes in a 500-W modular laboratory prototype that was built with the necessary flexibility to allow the realization of each different topology.

III TRANSFORMER VERSIONS OF BUCK CONVERTER

In many dc power supplies, a galvanic isolation between the dc or ac input and the dc output is required for safety and reliability. An economical mean of achieving such isolation is to employ a transformer version of a dc–dc converter. High-frequency transformers are of a small size and weight and provide high efficiency. Their turn’s ratio can be used to additionally adjust the output voltage level. Among buck-derived dc–dc converters, the most popular are: forward converter, push–pull converter, half-bridge converter, and full-bridge converter.

A. Forward Converter

The circuit diagram of a forward converter is depicted in Fig. 3.1. When the switch S is on, diode D1 conducts and diode D2 is off. The energy is transferred from the input, through the transformer, to the output filter. When the switch is off, the state of diodes D1 and D2 is reversed. The dc voltage transfer function of the forward converter is

$$M_V = \frac{D}{n}$$

Eq 3.1

where n = N1/N2

Eq 3.2

In the forward converter, the energy-transfer current flows through the transformer in one direction. Hence, an additional winding with diode D3 is needed to bring the magnetizing current of the transformer to zero. This prevents transformer saturation. The turns ratio N1/N3 should be selected in such a way that the magnetizing current decreases to zero during a fraction of the time interval when the switch is off.

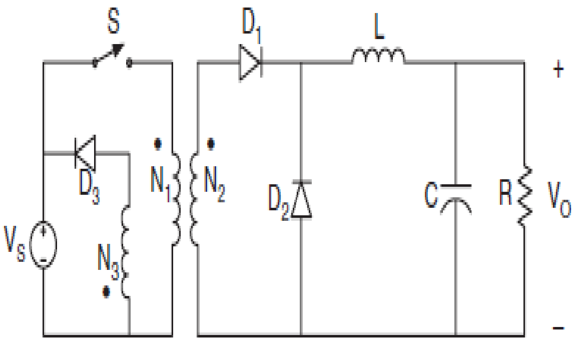

Figure 3.1: Forward converter.

3.2 Step-up (Boost) Converter

Figure 3.2 a depicts a step-up or a PWM boost converter. It is comprised of dc input voltage source VS , boost inductor L, controlled switch S, diode D, filter capacitor C, and load resistance R. The converter waveforms in the CCM are presented in Fig. 3.2 b. When the switch S is in the on state, the current in the boost inductor increases linearly. The diode D is off at the time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the input RC circuit. Using the Faraday's law for the boost inductor

$$V_S DT = (V_O - V_S)(1 - D)T$$

Eq 3.3

from which the dc voltage transfer function turns out to be

$$M_V \equiv \frac{V_O}{V_S} = \frac{1}{1 - D}$$

Eq 3.4

As the name of the converter suggests, the output voltage is always greater than the input voltage. The boost converter operates in the CCM for L >Lb where

$$L_b = \frac{(1 - D)^2 DR}{2f}$$

Eq 3.5

For D = 0.5, R = 10_, and f = 100 kHz, the boundary value of the inductance is Lb = 6.25μH. As shown in Fig. 3.9b, the current supplied to the output RC circuit is discontinuous. Thus, a larger filter capacitor is required in comparison to that in the buck derived converters to limit the output voltage ripple.

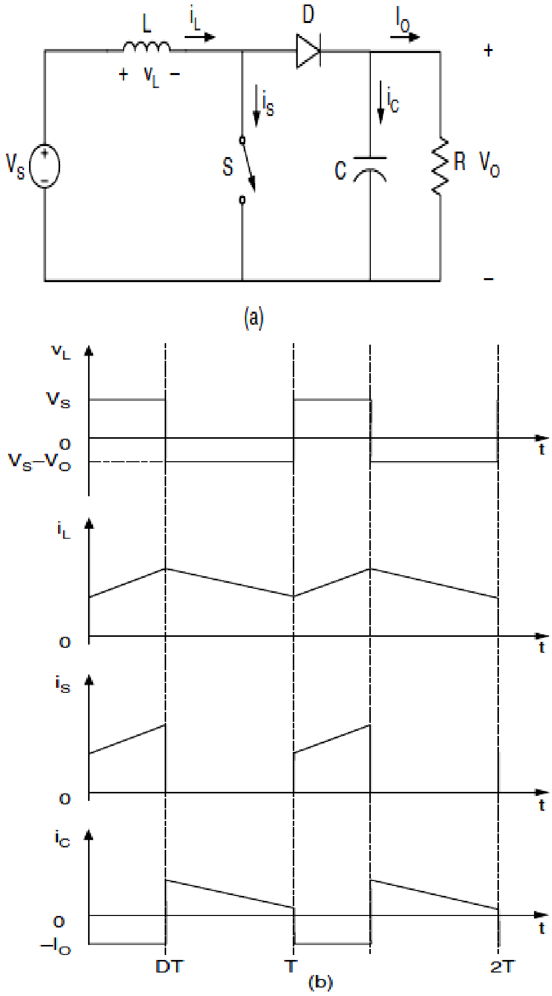

Figure 3.2: Boost converter (a) circuit diagram (b) waveforms.

The filter capacitor must provide the output dc current to the load when the diode D is off. The minimum value of the filter capacitance that results in the voltage ripple Vr is given by

$$C_{min} = \frac{DV_O}{V_r Rf}$$

Eq 3.6

At D = 0.5, Vr /VO = 1%, R = 10_, and f = 100 kHz, the minimum capacitance for the boost converter is Cmin = 50μF. The boost converter does not have a popular transformer (isolated) version.

3.3 Buck–Boost Converter

A non-isolated (transformerless) topology of the buck–boost converter is shown in Fig. 3.3 a. The converter consists of dc input voltage source V_S , controlled switch S, inductor L, diode D, filter capacitor C, and load resistance R. With the switch on, the inductor current increases while the diode is maintained off.

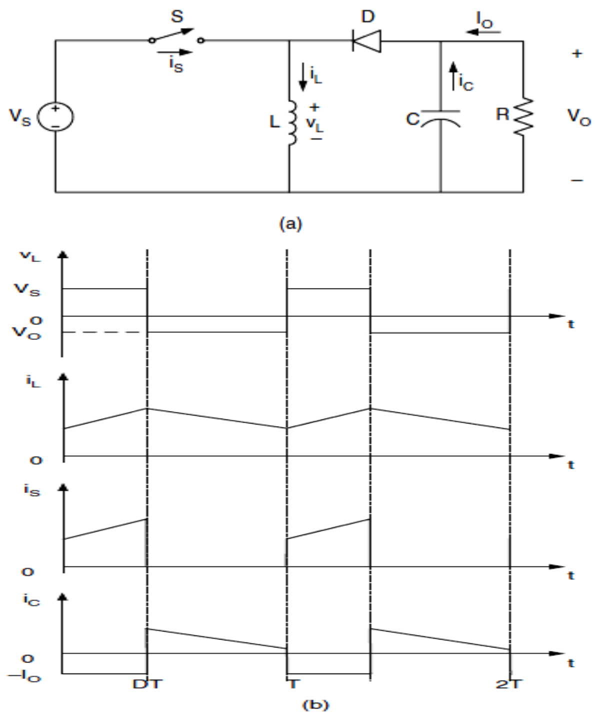

Figure 3.3: Buck-boost converter (a) circuit diagram (b) waveforms.

When the switch is turned off, the diode provides a path for the inductor current. Note the polarity of the diode which results in its current being drawn from the output. The buck–boost converter waveforms are depicted in Fig. 3.3 b. The condition of a zero volt–second product for the inductor in steady state yields

IV CONCLUSION AND FUTURE SCOPE

A simple and effective boost converter is proposed which has many advantages like: - power factor correction. Less number of semiconductor devices are used. Easy control techniques. As the power factor plays very important role in power system so it is very necessary to improve power factor. By using this converter output power factor is corrected and thus harmonics are reduced.

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