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Buck Boost AC Chopper

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Abstract

A simple voltage converter based on LC network is capable of boosting and bucking the voltage level of input supply without any phase difference. The paper presents the working principle and elaborates performance evaluation of this converter in different operating conditions. The number of reactive components and switches used in the circuit is minimum. High speed MOSFET are used as bi-directional switch of the ac-ac converter and it is able to deliver smooth variable output voltage across the load without using any additional filter. The optimize use of the LC network helps to make the circuit simple, cost-effective and small size.
Keywords: Ac-ac Converter; Z-Source Converter; Buck-Boost converter; low Cost L

I. INTRODUCTION

Different types of power quality problems exist in our power system like transients, voltage sags/ surges, harmonics etc. Many devices have been developed to perform the role of conditioning, purifying, regulating incoming power with adequate power quality standard. Among these problems, short term voltage fluctuations, i.e. voltage surge and voltage sags, constitute the major disturbances and have the largest negative impact on industrial productivity as well as on rural electrification. There are also many sensitive load devices today that cannot withstand this voltage fluctuation and cause frequent failures [3]. Most voltage variations are due to different power circuit faults, line losses or major changes of load current.

Ac to ac power conversion is the most popular way to generate quality ac power after the introduction of power electronics. Traditionally, an ac voltage converter is made with a transformer tap changer or with an ac-ac converter based on buck topologies or through ac-dc-ac converter. Developments of different topologies and switching techniques make ac-ac converter more versatile.

There are two major areas where ac–ac power conversion is necessary. One is the popular v-f ac drive where output voltage and output frequency both are required to be variable. The most popular topologies for such application are indirect ac–ac converters with a dc link [1]-[3], and matrix converters [7]. However, in another case where only voltage variation or regulation is needed with no change in frequency, direct PWM ac–ac converters are used, and they perform as ac choppers or power line conditioners. They have some advantages like the provision of better power factor, efficiency, low harmonic current in line, ease of control, smaller size and lower cost. Moreover, it is a single-stage conversion with simple topology. The traditional direct PWM ac–ac converters are implemented by bi-directional ac thyristor power controllers or triac, which use phase angle or integral cycle control of the ac supply to obtain the desired output voltage. However, they have some disadvantages, such as high total harmonic distortion (THD) in the source current, low power factor, and poor power transfer efficiency. Moreover, they do not have any facility of boosting the input voltage without using transformer in the circuit. Recently, Z-source converters applied to ac–ac converters have been proposed in [4]-[5]. In the concept of z-source ac to ac converter, two switches (either single-directional with dc rectifier or bi-directional) are turned on and off in complement with PWM signals. This circuit proposed with high frequency switching is used for boost mode but contains harmonics at the output waveform that requires filter to get smooth output. A new topology PWM buck-boost ac-ac converter using regenerative DC snubbers is proposed and analyzed in [6]. However, the output voltage of the proposed circuit is lagging the input voltage and additional output voltage filtering is required in this topology.

In this paper, the single-phase voltage-fed LC network power converter is presented with a different kind of simple switch topology. The most important achievement resulting from this technique is the reduction of the size and weight of the system. Furthermore, this ac-ac converter can be considered an electronic power transformer.

II. PROPOSED CIRCUIT MODEL

Ac-ac converter based on single-phase LC network is shown in block diagram in Fig. 1(a). The main ac to ac converter block consists of the ac single phase source, an LC-network and two bi-directional switches. The load may be resistive or inductive. The LC-network, a combination of one inductor and one capacitor as shown, is the main elements here that store or release energy accordingly to drive the circuit at a buck or boost mode.

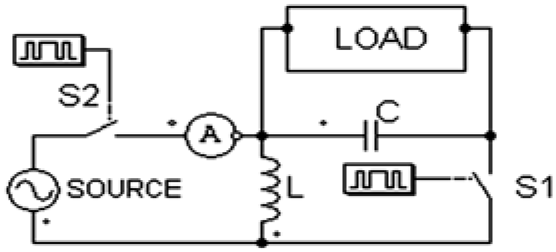

Fig. 1: (a) Block diagram of the proposed system

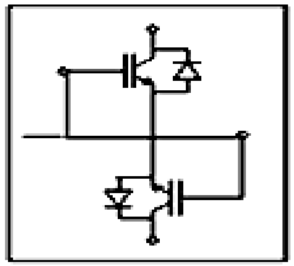

Fig. 1: (b) Bidirectional switch configuration

The bidirectional switch s1, s2 as shown in Fig. 1(b) are able to block voltage and to conduct current in both directions. The s1 and s2 are provided PWM high frequency switching pulses, complement to each other. Here, a bi-directional switch is realized as a set of two mosfet connected in common source mode back to back with two diodes. The diodes are included to provide the reverse blocking capability. The higher value of switching frequency of PWM signal is selected to keep the value of inductor and capacitor of LC network low. When the switch s2 is on as shown in Fig.2 (a), the inductor L stores electromagnetic energy from the ac source. At the same time, switch s1 is off and the capacitor C discharges through the load. When the switch s2 is off and s1 is on, as shown in Fig. 2(b), the stored energy of the inductor supplies current to charge the capacitor C and to provide load current through switch s1.

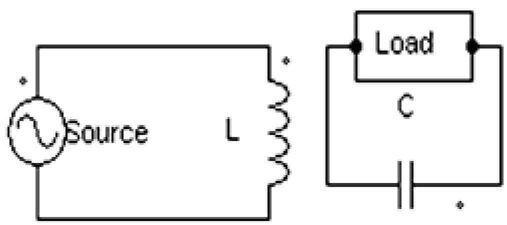

Fig. 2: Equivalent circuit (a) when switch s2 is on and s1 is off

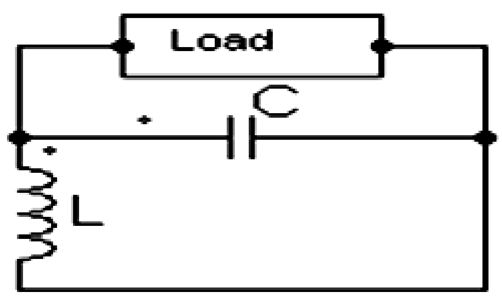

Fig. 2: (b) when switch s2 is off and s1 is on

III. SIMULATIONS RESULTS

The single phase ac-ac converter has the capability to buck/boost voltage, and this can be used to overcome voltage sag or voltage rise in power system. Simulation was carried out first with a fixed ac input voltage and a range of increasing value of duty ratio. The LC- network was selected as C= 10 uF, L= 500 µH. A R-L type load was selected with R=500 KΩ, 1 mH for the simulation. The frequency of the PWM switching signal was chosen as 1 KHz. The set of obtained data during a number of simulations is shows that the voltage and currents across L and C increased with the increase of duty ratio.

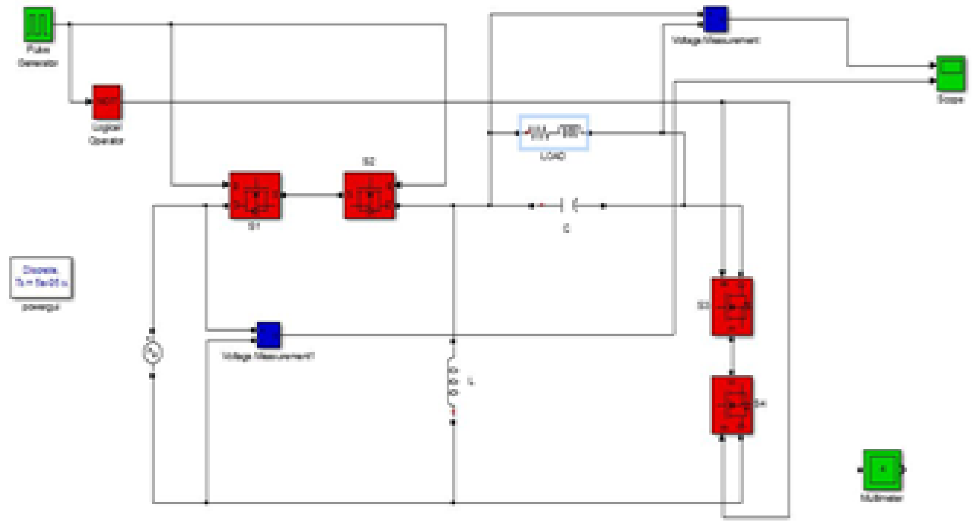

Fig. 3: Simulation diagram

Two sets of waveforms were recorded for 60% and 40% duty cycles respectively. Input voltage and corresponding load voltage and current, capacitor and inductor currents, inductor voltage were recorded through scope and are presented in Fig. 4(a),(b) and Fig. 5(a),(b), respectively. The voltage across capacitor Vc is the same with the load voltage as it is connected across the load. It is required to note that there is no phase difference between load and input voltages. Moreover, no additional filter was used to get smooth sinusoidal output voltage across the load for this topology.

A. Wave Form For 60% Duty Cycle:

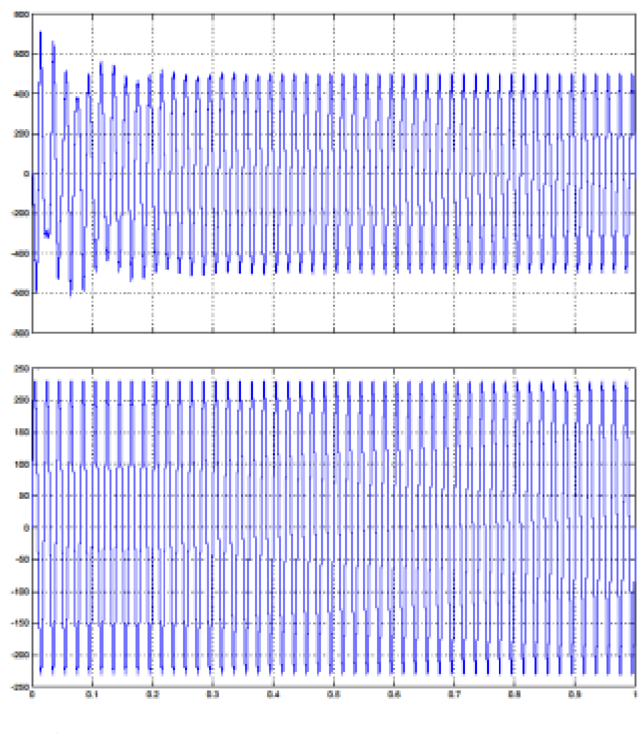

Fig. 4: (a) output and input voltage

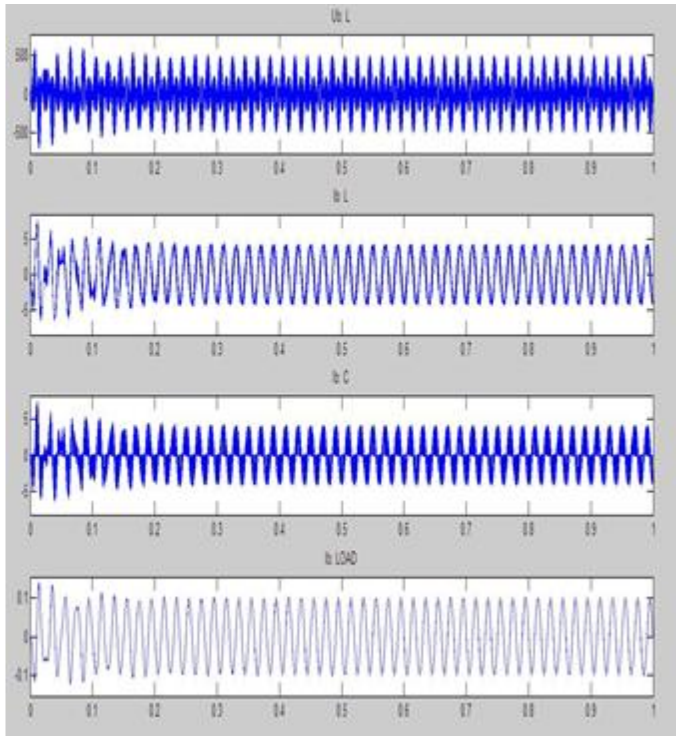

Fig 4: (b) Inductor Voltage & Current, capacitor current, Load current

B. Wave Form For 40% Duty Cycle:

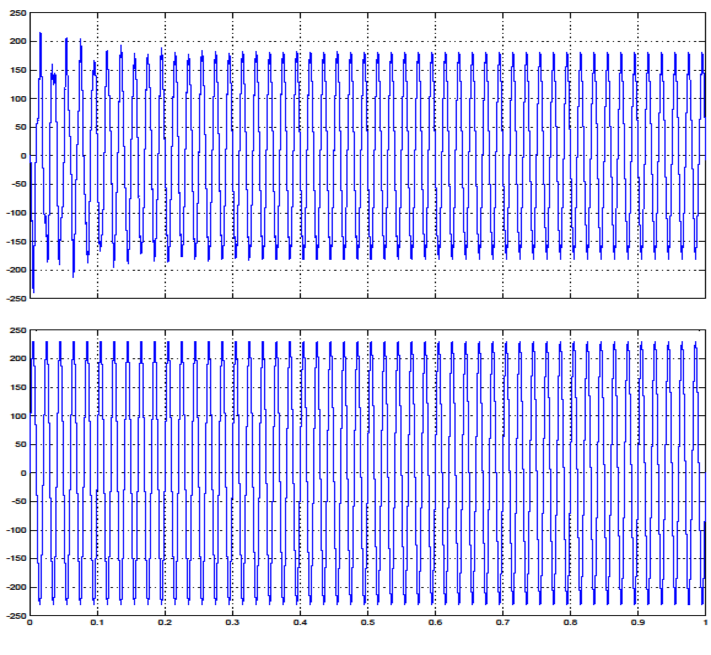

Fig. 5: (a) output and input voltage

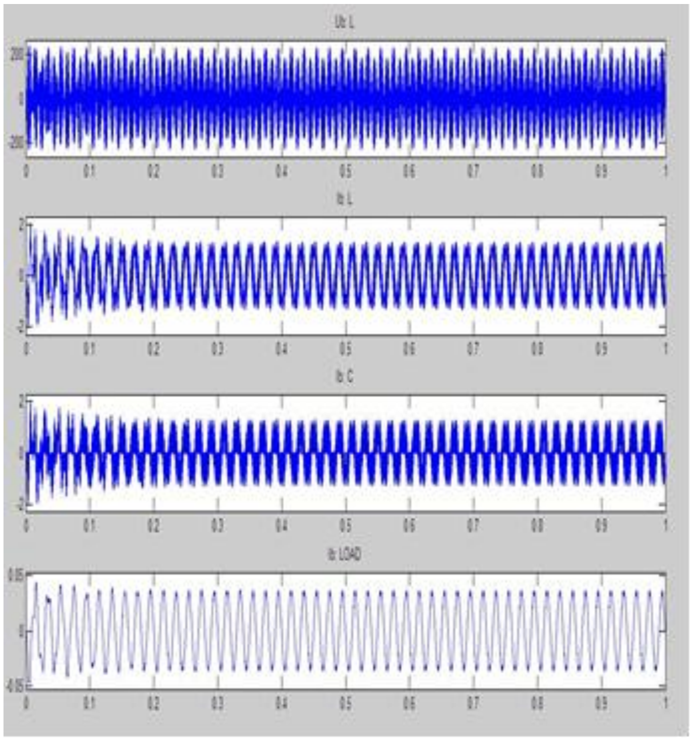

Fig 5: (b) Inductor Voltage & Current, capacitor current, Load current

IV. CONCLUSION

Performance study was done in this study through simulation for the simple topology single- phase ac-ac converter based on LC network. The single-phase ac-ac converter can provide variable output voltage under steady state condition by operating at boost and buck mode. Operating principle and steady-state analysis of the system was presented in different operating conditions. The effects of different components and operating parameters were studied in detail, which will help to optimize the design of converter. It will help to reduce the size and cost of the converter. This converter can be effectively used in closed loop systems to develop power conditioner or voltage regulator. The merit of getting smooth sinusoidal waveform of same phase is possible here without using any additional filter circuit, making this converter popular.

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