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Implementation of Highly efficient AC Chopper using Bi-directional Switches

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Abstract - After the evolution of Power Electronics in recent years the conversion from Ac to Ac power has been drastically improved. This paper describes modified version of AC Buck-Boost Voltage regulator. Voltage regulator is capable of Bucking & Boosting of supply voltage in any desired manner. Here, a highly efficient AC chopper circuit is presented on Matlab. Thus, performance characteristics & its analysis has been carried out on a fixed input parameters. The proposed model does not contain any transformer, thus, various transformer losses are reduced. Also it does not contain any DC component, thus, it is a direct AC to AC converter.

Key Words: Single phase AC Chopper, Buck-Boost operation, Bidirectional Switches.

1. INTRODUCTION

Traditionally in industry, the ac-ac power conversions are performed by using ac thyristor power controllers, which use the phase angle or integral cycle control on input ac voltage, to get the desired output ac voltage. However, the obvious disadvantages of ac thyristor controllers such as low power factor, large total harmonic distortion in source current and lower efficiency, have limited their use. For ac-ac power conversions with variable frequency and voltage, the use of indirect ac-ac converters with dc-link , and matrix converters have been advanced because they can obtain better power factor and efficiency, and smaller filter requirements. However, for applications in which only voltage regulation is needed, the direct PWM ac-ac Converters.

All of these direct PWM AC – AC converters in are obtained from their dc-dc counterparts, where all bidirectional devices .However, each topology has its own limitations; the buck type ac-ac converter, can only step-down the input voltage while boost type can only step-up the input voltage. The buck-boost and Cuk topology can both step-up and step-down the input voltage, however, the phase angle is reversed. Moreover, both topologies have disadvantage of higher voltage stress across switches, and there are discontinuous input and output currents in case of the buck-boost converter. The Cuk topology can overcome the currents discontinuity but at the cost of additional passive components; increasing the size and cost of converter and decreasing the efficiency .All of the direct PWM ac-ac converters have a common commutation problem, which occurs because compared to the ideal situation in which the complementary.

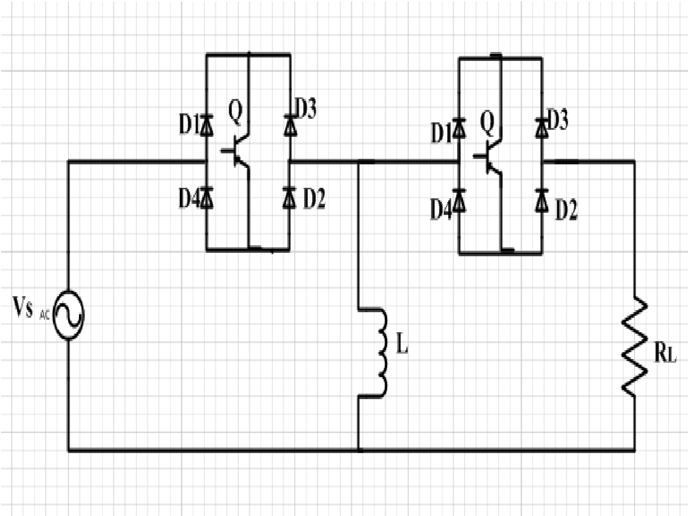

Fig. 1 AC-AC PWM Buck-Boost converter.

2. Methodology:

The new ac-ac buck-boost regulator circuit is derived from its counterpart topology used for dc-dc conversion. The input to the regulator is ac and the switch used is a bi- directional switch, which is made of a unidirectional switch combined with four diodes. It is envisaged that ac-ac conversion by the buck-boost topology using a single bi-directional switch is possible by the philosophy of half cycle to half cycle conversion individually and connecting the outputs to the load either in wired OR, or in differential mode.

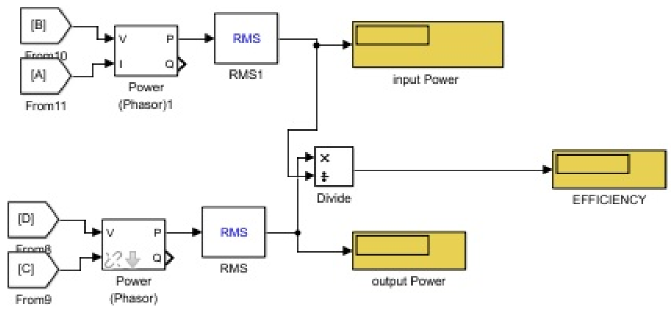

Fig.2 Block Diagram

Such conversion has the advantage of input current being in phase with supply voltage without additional sensing and control circuits and the high frequency chopped input current can be made near sinusoidal with small input filter resulting in low input current THD and high power factor. In the wired connection to the load both half cycles appear at the output load. In the differential connection average dc of the individual outputs are cancelled out and the load voltage lower than the expected peak to peak is available. In the differential mode of

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connection two quadrant operation of single switch converter in each positive and negative cycle of the supply voltage is necessary because path for current flow from load to source is necessary when the switch is OFF. Reducing the number of control switch makes the design simple, cost effective and reliable. Input current distortion to the circuit is in acceptable range and the circuit exhibit good performance in respect to input power factor, input current THD and efficiency in a given range of duty cycle. The proposed circuit is simulated using Matlab simulator and the performance of circuit is analyzed.

3. RESULTS & DISCUSSIONS

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. Two sets of waveforms were recorded for 40% and 60% duty cycles respectively. 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.

DUTY CYCLE	**VOLTAGE GAIN**	**p.f.**	η **%**
0.3	0.87	0.65	23
0.4	1.03	0.68	23.5
0.45	1.1	0.68	24.2
0.5	1.2	0.7	23.8
0.55	1.3	0.7	25.4
0.6	1.4	0.7	24.6
0.65	1.53	0.73	24.6
0.7	1.68	0.74	26.5

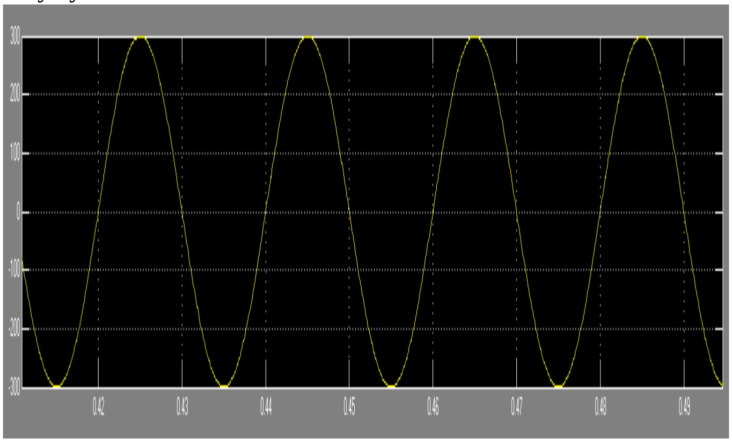
Table 1: Output result without input filter

The simulation results clearly show that this new ac-ac converter can operate in both inverting and non-inverting modes. That is, step down , step up and inverted outputs can be obtained from this single converter topology by adjusting the switching patterns of the switches. The proposed circuits provide controllable ac output with very low input current distortion and high input power factor. The efficiency of the circuits are predictably variable with change in duty cycle of the gate pulse of the controlling switch.

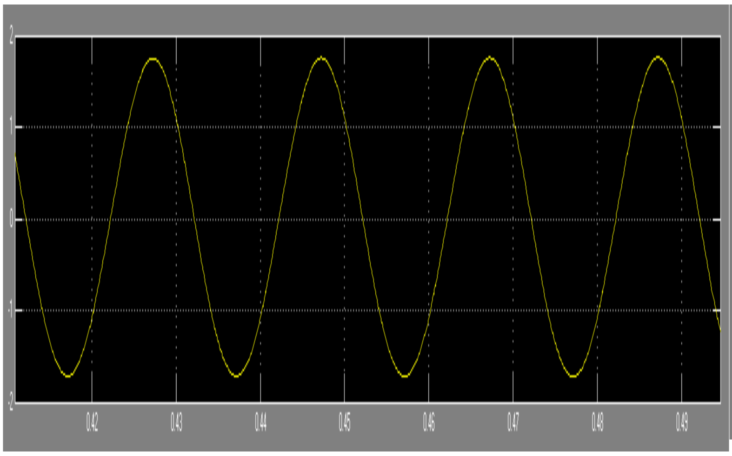
Table 2: Output of proposed Circuit

DUTY CYCLE	**VOLTAGE GAIN**	**p.f.**	η **%**
0.3	1.25	0.79	24.3
0.4	1.87	0.78	26.6
0.45	1.89	0.77	30.5
0.5	2.01	0.77	45.3
0.55	1.78	0.77	65.5
0.6	1.61	0.75	69.8
0.65	1.60	0.74	75.8
0.7	1.75	0.74	80.2

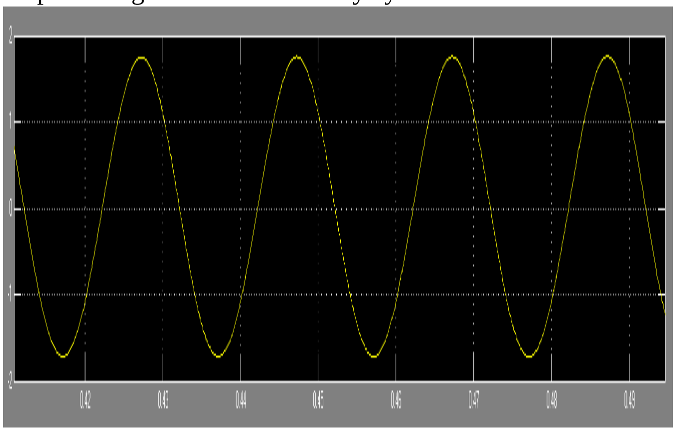
Input Voltage at 40% duty cycle: The amplitude is fixed at 300 V. This value can be changed accordingly. When we want to buck or boost the output we give gate pulse of 40% duty cycle.



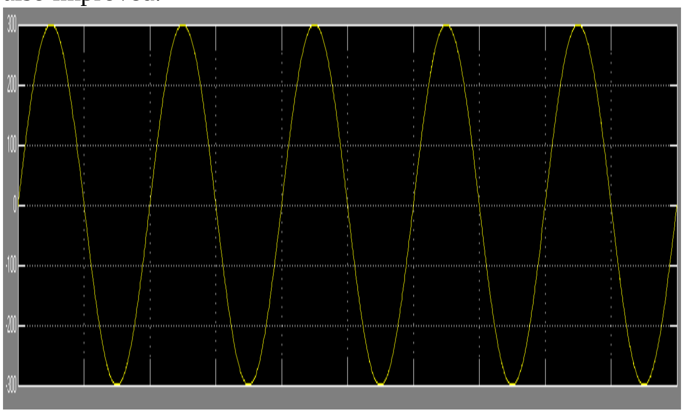
Output Voltage at 40% duty cycle: The amplitude of the output voltage is boosted up as compared to duty cycle of 30%.



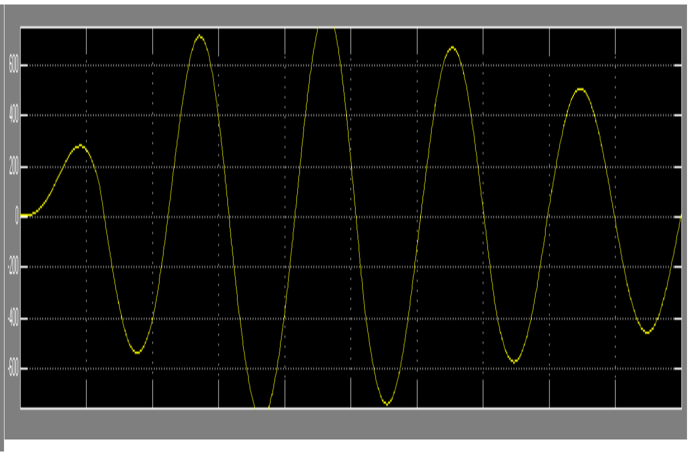
Output Current at 40% duty cycle: The output current is also boosted up with duty cycle of 40%.Whatever be the value of input voltage , the output current varies in accordance with the output voltage with the same duty cycle for both.



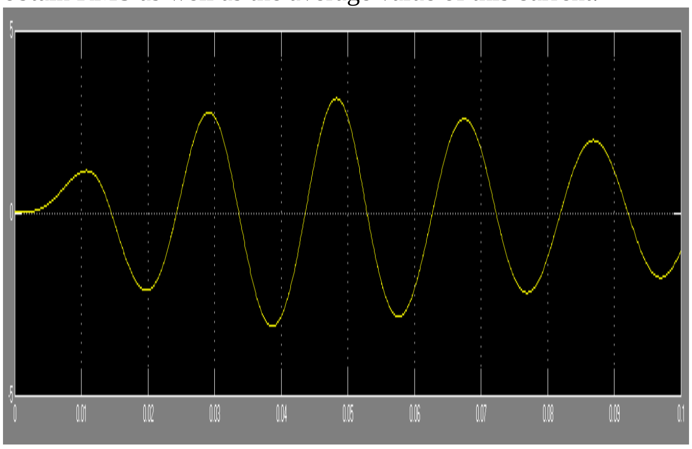
Input voltage at 60% duty cycle: When the input voltage is increased or decreased with 60% duty cycle the response of the input gives better efficiency and voltage gain. Power factor is also improved.



Output Voltage at 60% duty cycle: The output voltage with 60% duty cycle gives much better boosted voltage as compared to 40% duty cycle. Various parameters are considered for obtaining the desired output within a given range of duty cycles.



Output Current at 60% duty cycle: The output current depends on the output voltage. The peak amplitude of the current is increased as compared to lesser duty cycles. We can obtain RMS as well as the average value of this current.



3. CONCLUSIONS:

A new scheme for single phase AC-AC Buck-Boost converter is proposed that has low input current THD and good input power factor. It also has acceptable efficiency for selective range of duty cycle. The proposed circuit does not require any additional control scheme to reduce harmonics. Based on the results obtained from simulation , the proposed circuit can be considered for AC-AC conversion with low harmonic distortion, high input power factor and acceptable range of efficiency. The circuit is investigated and reported with low switching frequency which is desired for its applicability in medium & high power applications. The proposed AC-AC Buck-Boost converter circuit deliver promising aspects.

4. Recommendation for future work:

The proposed AC-AC Buck-Boost regulator will be implemented practically in laboratory in future. For the proposed circuit to obtain a good efficiency we have to vary both the duty cycle and switching frequency manually according to out requirements, but it is also possible to make an automatic control technique which can be done in future.

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