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A Novel High Performance Bridgeless Ac-Dc Boost Converter

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ABSTRACT: *A new single phase high performance bridgeless AC-DC Boost converter is proposed. The converter is made bridgeless by the use of two unidirectional switches and two diodes at the input ac side for power conversion for both positive and negative half cycle. Because of the high frequency switching, the power factor of the circuit is inherently corrected and it requires a small filter to make the input current near sinusoidal with limited THD. The significant improvement in THD makes the circuit a good choice in applications needing AC-DC conversion with power conditioning. The circuit exhibits such better performances than conventional AC-DC boost converter with variable loads at constant frequency switching with no additional control circuits. The efficiency of the circuit is also satisfactory. Analysis and simulation results of the circuit are obtained by using software simulation. The main advantage of this new AC-DC converter is its superior power quality over conventional AC-DC boost converter.*

Keywords: *AC-DC converter, Boost topology, Efficiency, Power Factor Correction (PFC), Total Harmonic Distortion (THD)*

I. INTRODUCTION

The Power quality of the ac system is of great importance due to the increasing use of newly developed power converters. Harmonic distortion in line current can affect the operation of other devices connected to the same power grid. To reduce harmonic distortion and improve the efficiency, active power factor correction (PFC) became necessary on power supplies. Initially, power factor correction schemes had been done mainly for heavy industrial loads like induction motors, heating furnaces etc. However, the trend is changing as electronic equipmentare increasingly being used in everyday life. Hence, PFC is becoming an important aspect even for low power application electronic equipment[4]-[7].

Active PFC makes the load behave like a pure resistor leading to near unity load power factor and at the same time generate lessTotal Harmonics Distortion (THD) in the input line current. SMPS (Switched Mode Power Supply) converters are very important in this aspect due to ease of application and scope of improvement. Traditionally used active PFC circuits and conventional SMPS AC-DC converters comprise of front-endfull bridge rectifier followed by high frequency DC-DC converter/s. As the power level increases, the conduction loss caused by the forward voltage drop of the diode bridge begins to deteriorate the overall efficiency, and the heat generated within the bridge rectifier may destroy the individual diode.Hence, conventional boost AC-DC converter suffers from demerits like usage of rectifier bridge, high diode loss in bridge, low efficiency, low power factor, high THD in input current.

Many bridgeless Boost configurations have been proposed in recent past for improvement of these drawbacks. Actually, these bridgeless PFC circuit combines the operation of bridge rectifier and DC-DC converter into a single circuit [1]-[3]. All these proposed configurations differ in their topology, and they have some drawbacks.Sometimes the proposed AC-DC converter is claimed as bridgeless, but it suffers from increased number of diodes leading to more power losses in diodes and less efficiency.In [8]-[9], the proposed boost converter only works on very small voltage, and shows very little efficiency and low power factor at typical supply voltage and load. In [10], proposed boost rectifier suffers from low efficiency at typical supply voltage and at low output power. It also shows low power factor at small load and at low output power. To removeall these drawbacks it requires animproved AC-DC boost converter of high performance over conventional AC-DC boost converter.

In this paper, a single phase bridgeless AC-DC Boost converter is proposed. A bridgeless configuration is made by two unidirectional switches and two diodes. A new switching mechanism is used as only one switch is active in each cycle. This leads to less switching loss and overall improved efficiency. Because of the high switching frequency a small input filter is required to suppress the ripple in the input current. As a result this proposed circuit provides better performance with respect to THD of the input current in comparison with the conventional converter. Moreover, it shows improved power factor correction mechanism than the conventional converter.

II. CIRCUIT CONFIGURATION

Fig. 1 show a basic Boost topology based single phase AC-DC converter that can rectify both positive and negative half cycle of the input individually. In the positive cycle of the input signal AC-DC conversion is performed through diodes D1, D4 and D5, switch S, inductors L1, capacitors Coand load RL; while during the negative cycle of the input signal diodes D2, D3 and D5, switch S, inductors L1, capacitor Co and load RL are used for rectification.

Fig. 2 is the proposed bridgeless Boost AC-DC circuit which is basically constructed by the use of two unidirectional switches and two diodes. Unlike the conventional converter, two switches S1 and S2 get two different kind of gate pulses. The detailed operation of the proposed circuit is given in next section.

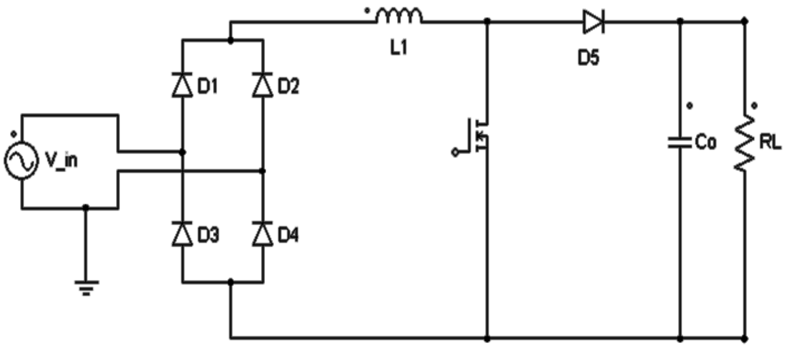

Fig.1. Conventional Boost AC-DC converter

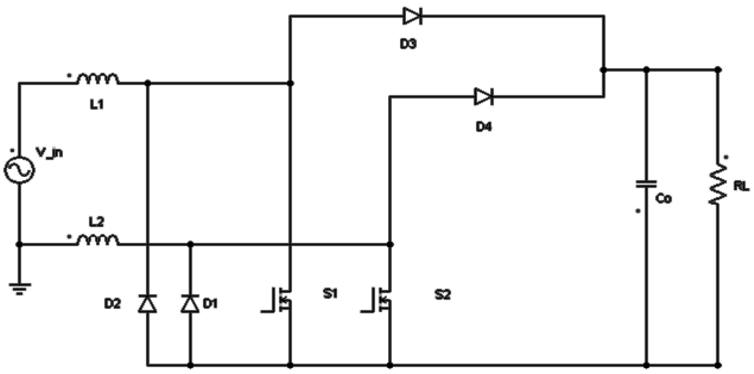

Fig.2. Proposed Boost AC-DC converter

III. PRINCIPLE OF OPEARTION

In the proposed circuit in Fig.2, two switches S1 and S2 get two different kind of gate pulses G1 and G2 respectively as shown in fig.3. The two gate pulses G1 and G2 are created by the circuit of fig.4. The operation of the proposed circuit can be explained by splitting it into two different circuits for each positive and negative half cycle. In positive half cycle, only switch S1 becomes ON by getting gate pulse G1, while in the negative half cycle only switch S2 becomes ON by getting gate pulse G2. Thus the operation can be explained by four mode of conduction in two half cycles as in Fig.5. Mode 1 shows the circuit components to be activated during positive half cycle when the S1 is ON (S2 is OFF). Mode 2 shows the circuit components to be activated during positive half cycle when the S1 is OFF (S2 is OFF). Mode 3 shows the circuit components to be activated during negative half cycle when the S2 is ON (S1 is OFF). Mode 4 shows the circuit components to be activated during negative half cycle when S2 is OFF (S1 is OFF). Return diodes D1 and D2 can be taken as the reverse diodes of the two MOSFET switches.

3.1 Voltage gain

It is found from calculation that the voltage gain of the proposed converter is the same as that of conventional converter.Voltage gain $=\frac{1}{1-D}$, where D is the Duty cycle.

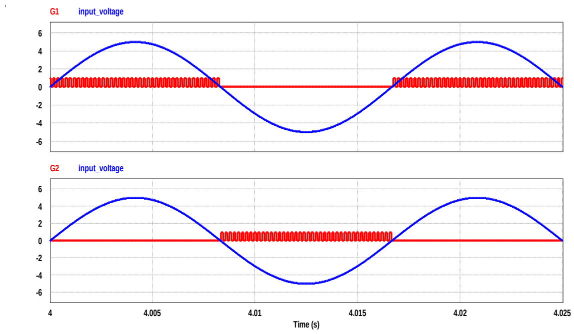

Fig.3. Gate pulses G1, G2

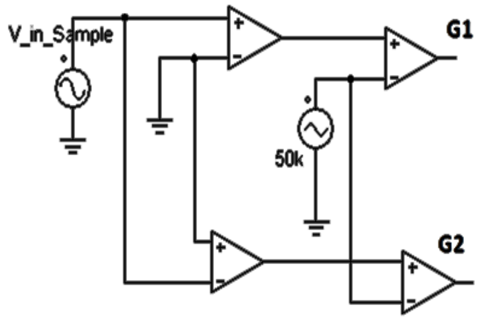

Fig.4. Circuit to produce the gate pulses G1, G2

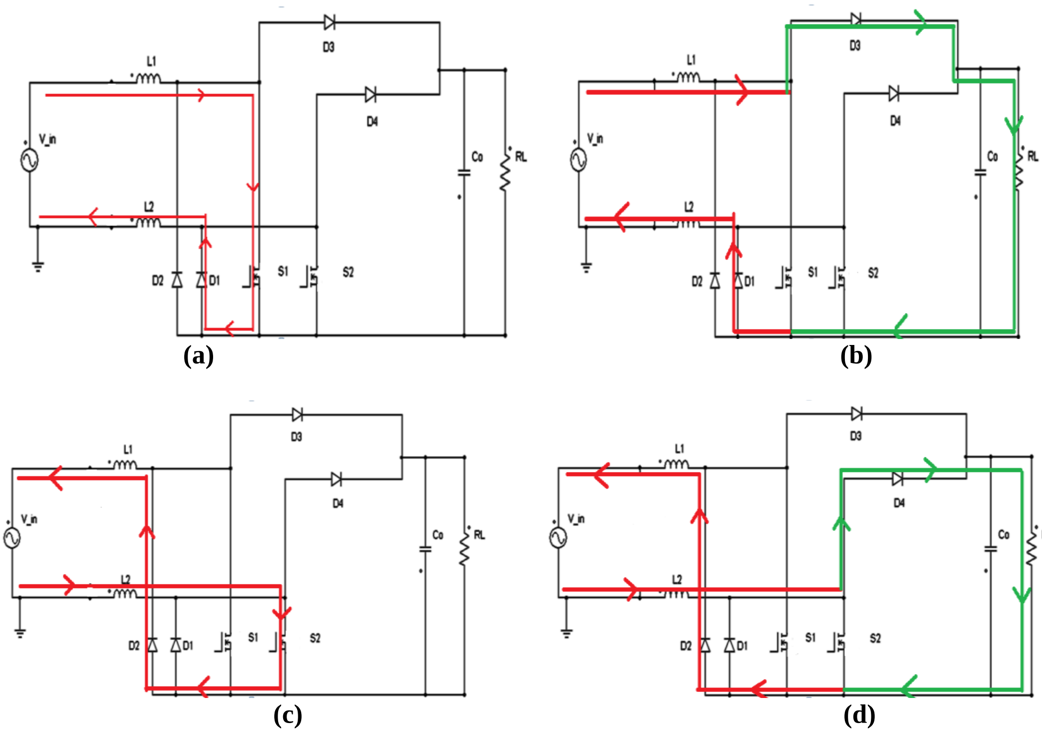

Fig.5. Four modes of operation of proposed AC-DC Boost converter, (a) Mode 1: Proposed circuit in positive half cycle when S1 is ON. (b)Mode 2: Proposed circuit in positive half cycle when S1 is OFF. (c) Mode 3: Proposed circuit in negative half cycle when S2 is ON. (d) Mode 4: Proposed circuit in negative half cycle when S2 is OFF.

IV. PERFORMANCE OF THE PROPOSED CIRCUIT

The simulation of the proposed circuit is performed using PSIM software and the results obtained are presented in Table II. MOSFETis considered as the switching device. The value of different circuit components are given in Table I.

TABLE I. Parameter table

Parameters	Value
Input Voltage (V_in)	110 V (amplitude), 60 Hz
Switching frequency	50 KHz
Inductor (L1, L2)	2.2 mH
Capacitor (Co)	220uF
load resistance(RL)	20Ω

The proposed circuit has been compared with the conventional single phase AC-DC Boost converter consisting of diode bridge rectifier for AC-DC conversion followed by DC-DC Boost converter using same circuit parameter values. The obtained results are presented in the next subsection.

4.1 Result from Simulation

The typical wave shapes of input voltage, input current and output voltage for the proposed Boost AC-DC converter is shown in Fig. 6. It is evident from the wave shapes obtained that the output voltage of the proposed Boost AC-DC converter is a DC voltage. The input current is almost sinusoidal with negligible harmonic components which can be improved by additional controller.

4.2 Quantitative Comparison

Table II shows the comparative analysis of conventional circuit with the proposed circuit for duty cycle variation. Both the circuits are switched at 50 KHz.In the conventional circuit highfrequency chopping is performed on the rectified output whereas in the proposed circuit the switching is done in the input side. It depicts that efficiency of both the conventional and proposed Boost converter is good for all the range of duty cycles. Power Factor of the proposed circuitis better than that of the conventional one except for the high duty cycles. But in respect to THD the proposed circuit shows superior performance than the conventional AC-DC converter in all ranges of duty cycle.The power factor and THD of the proposed circuit can be further improved by implementing Average Mode Current Control.

In Table III the circuit performance under load variation is justified for both conventional and proposed converter for the switching frequency 50 KHz and duty cycle 0.1. Fig.7 graphically shows the performance of conventional to proposedBoost converter with respect to efficiency, input current THD and power factor for duty cycle variation. Fig.8 shows the performance for load variation of the proposed circuit and the conventional one. It is evident from the table that the circuit performance of the proposed converter shows better performance than the conventional converter under load variation with respect to the measured parameters.

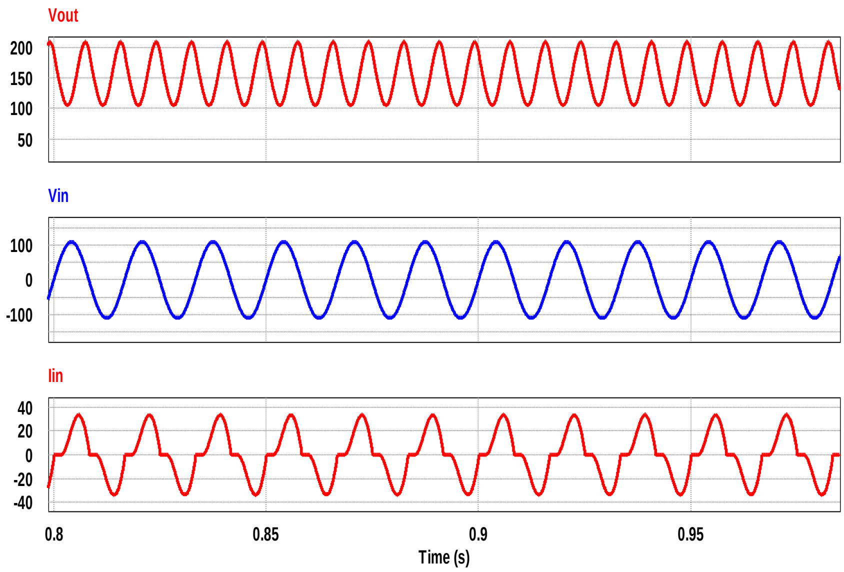

Fig.6. The typical wave shapes of Output Voltage, input voltage and Input Current for the proposed circuit

TABLE II: Performance Comparison under Duty Cycle Variation

Duty Cycle	Proposed Converter			Conventional Converter		
	Efficiency (%)	Power factor	THD (%)	Efficiency (%)	Power factor	THD (%)
0.1	99.99	0.87	56.8	99.99	0.77	75.62
0.2	99.99	0.88	50.9	99.99	0.81	68.84
0.3	99.98	0.87	44.5	99.99	0.85	61.55
0.4	99.98	0.854	37.5	99.98	0.87	53.66
0.5	99.98	0.81	30.0	99.98	0.87	44.9
0.6	99.97	0.75	26.2	99.97	0.84	34.9
0.7	99.96	0.69	25.5	99.97	0.77	42.07
0.8	99.95	0.64	25.4	99.96	0.87	47.26
0.9	99.94	0.62	24.7	99.90	0.89	48.27

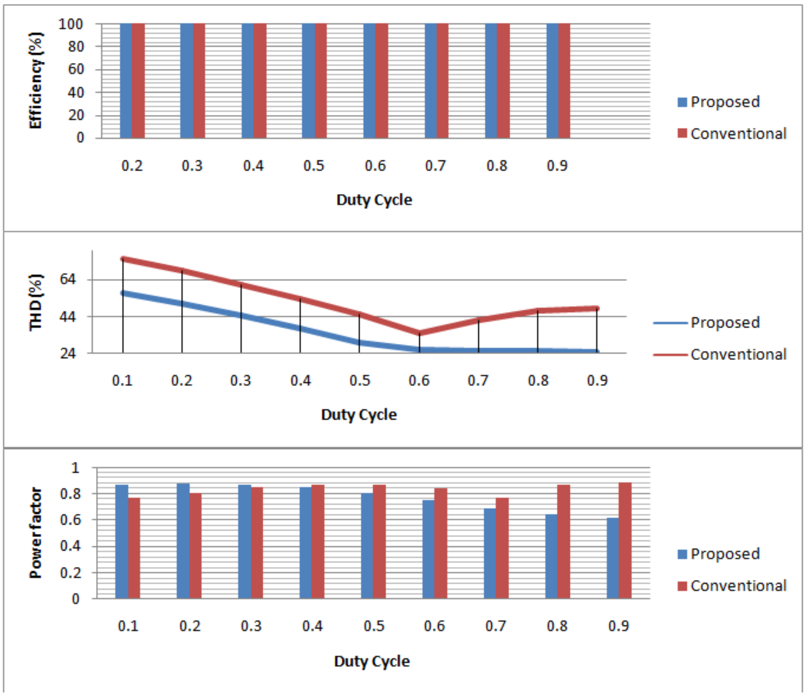

Fig.7. Efficiency, Input current THD and power factor comparison for the proposed AC-DC Boost converter with Conventional Boost converter

TABLE III: Comparison of Load Variation for the Proposed and Conventional Boost Converter

Load (Ω)	Proposed Circuit			Conventional Circuit		
	Efficiency (%)	Power factor	THD (%)	Efficiency (%)	Power factor	THD (%)
20	99.99	0.87	56.8	99.99	0.77	75.62
40	99.99	0.81	70.15	99.98	0.74	89.02
60	99.98	0.77	77.24	99.98	0.72	95.78
80	99.98	0.76	82.26	99.97	0.70	100.5
100	99.97	0.74	86.18	99.96	0.68	104.2
120	99.97	0.73	89.42	99.96	0.67	107.2
140	99.96	0.72	92.17	99.95	0.66	109.8
160	99.96	0.71	94.6	99.95	0.66	112.14
180	99.95	0.70	96.7	99.94	0.65	114.1
200	99.95	0.70	98.7	99.93	0.64	115.9

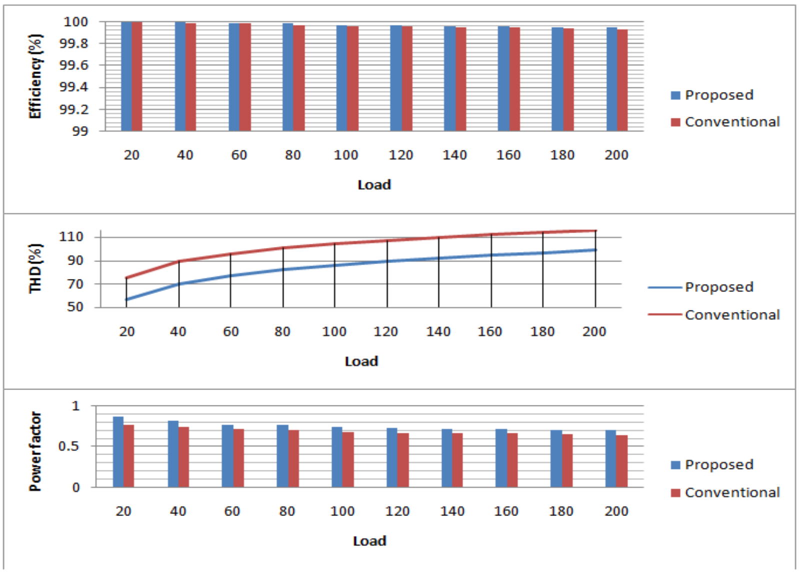

Fig.8: Efficiency, Input current THD and power factor comparison for proposed AC-DC Boost with Conventional Boost converter under load variation

V. CONCLUSION

A new scheme for single phase AC-DC Boost converter is proposed. The circuit chops the input current at the AC side in contrast to the conventional scheme which chops the rectified output. Comparison with conventional circuit to the proposed one has been made. The proposed scheme demonstrates better performance having lower input current THD, higher power factor and comparable efficiency. Moreover, it does not require any additional control schemes in order to reduce the harmonics. Based on the results obtained from simulation, the proposed scheme can be considered as a better choice for AC-DC Boost converter than the conventional AC-DC Boost Converter in the applications like hybrid electric vehicles (HEV), Battery power systems etc.

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