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A Proficient AC/DC Converter with Power Factor Correction

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ABSTRACT: *Dc power supplies are extensively used inside most of electrical and electronic appliances such as in computers, televisions, audio sets and others. Power supplies make the load compatible with its power source. The presence of nonlinear loads results into low power factor operation of the power system. Several techniques for power factor correction and harmonic reduction have been reported and a few of them have gained greater acceptance over the others. In this paper a bridgeless power factor correction boost converter is proposed which results in improved power factor and reduced harmonics content in input line currents as compared to conventional boost converter topology. Bridgeless power factor correction boost converter eliminates the line-voltage bridge rectifier in conventional boost power factor correction converter, so that the conduction loss is reduced.*

Keywords: *Power Factor Correction (PFC), Conventional Boost converter, Bridgeless PFC Boost converter, Total Harmonic Distortion (THD), Power factor.*

I. INTRODUCTION

The extensive use of dc power supplies inside most of electrical and electronic appliances lead to an increasing demand for power supplies that draw current with low harmonic content & also have power factor close to unity.

Dc power supplies are extensively used inside most of electrical and electronic appliances such as in computers, audio sets, televisions, and others. The presence of nonlinear loads results in low power factor operation of the power system. The basic block in many power electronic converters are uncontrolled diode bridge rectifiers with capacitive filter. Due to the non-linear nature of bridge rectifiers, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines. The bridge rectifiers contribute to high THD, low PF, and low efficiency to the power system. These harmonic currents cause several problems such as voltage distortion, heating, noises etc. which results in reduced efficiency of the power system. Due to this fact, there is a need for power supplies that draw current with low harmonic content & also have power factor close to unity.

The AC mains utility supply ideally is supposed to be free from high voltage spikes and current harmonics. Discontinuous input current that exists on the AC mains due to the non-linearity of the rectification process should be shaped to follow the sinusoidal form of the input voltage. Power factor correction techniques are of two types – passive and active. While, passive power factor correction techniques are the best choice for low power, cost sensitive applications, the active power factor correction techniques are used in majority of the applications due to their superior performance.

The continuous-conduction mode (CCM) conventional boost topology has been widely used as a PFC converter because of its simplicity and high power capability. Recently, in order to improve the efficiency of the front-end PFC rectifiers, many power supply manufacturers have started considering bridgeless power factor correction circuit topologies. Usually, the bridgeless PFC topologies, also known as dual boost PFC rectifiers, reduce the conduction loss by reducing the number of semiconductor components in the line current path.

II. CONVENTIONAL PFC BOOST CONVERTER

The conventional input stage for single phase power supplies operates by rectifying the ac line voltage and filtering with large electrolytic capacitors. This process results in a distorted input current waveform with large harmonic content. As a result, the power factor becomes very poor (around 0.6). The reduction of input current harmonics and operation at high power factor (close to unity) are important requirements for good power supplies.

The conventional boost topology is the most widely used topology for power factor correction applications. It consists of a front-end full-bridge diode rectifier followed by the boost converter. The diode bridge rectifier is used to rectify the AC input voltage to DC, which is then given to the boost section. This approach is good for a low to medium power range applications. For higher power levels, the diode bridge becomes an important part of the application and it is necessary to deal with the problem of heat dissipation in limited surface area.

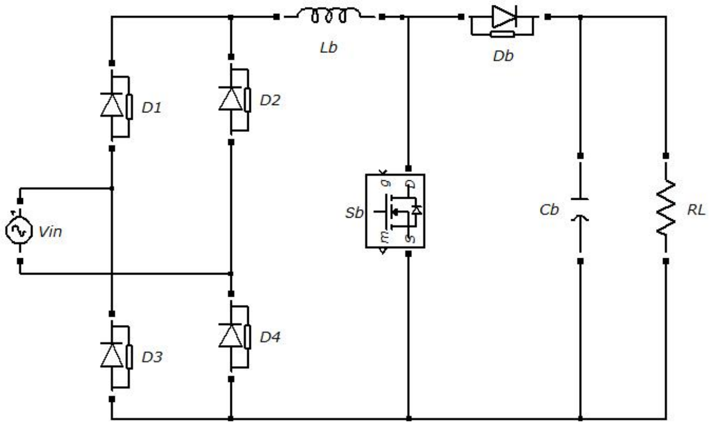

FIG1. CONVENTIONAL PFC BOOST

III. BRIDGELESS PFC BOOST CONVERTER

The operation of bridgeless power factor correction boost converter can be divided into four modes. Modes I and II comes under positive half cycle of input voltage and modes III and IV comes under the negative half cycle of input voltage.

1. Positive half cycle: During the positive half cycle of the input voltage, the first dc/dc boost circuit, LB1-D1–S1 is active through diode D4. Diode D4 connects the ac source to the output ground. The positive half cycle operation can be divided into two modes (Mode I and Mode II).

During mode I operation, the switch S1 is in on condition. When switch S1 turns on, inductor LB1 stores energy through the path Vin-LB1-S1-D4.

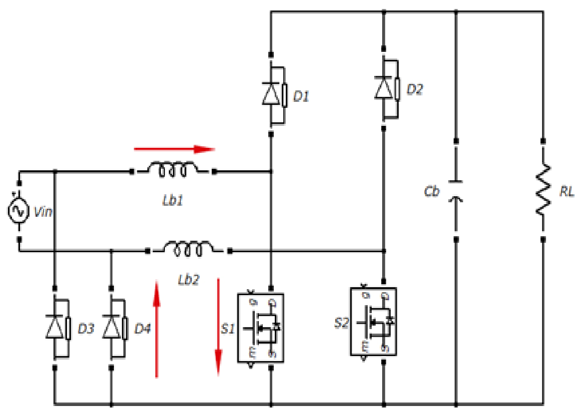

Fig. 3(a) Mode I operation

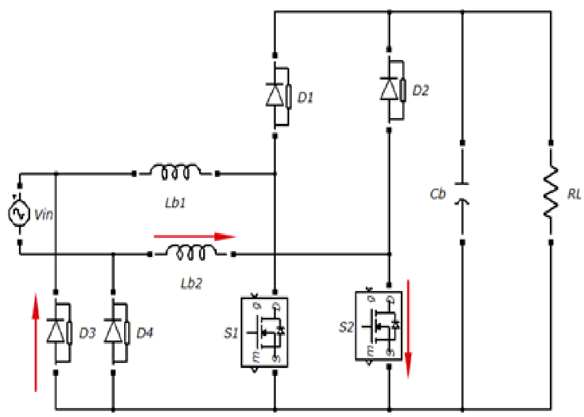

Fig. 3(b) Mode II operation

During mode II operation, the switch S1 is in off condition. When switch S1 turns off, the energy stored in the inductor LB1 gets discharged and the current flows through diode D1, load RL, and returns back to the mains through the diode D4.

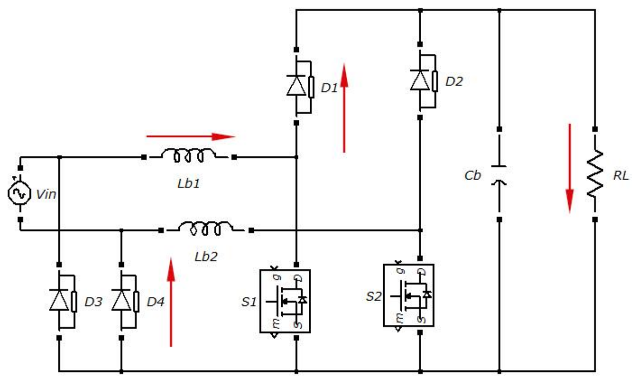

Fig. 3(c) Mode III operation

2. Negative half cycle: During the negative half cycle of the input voltage, the second dc/dc boost circuit, LB2-D2–S2 is active through diode D3. Diode D3 connects the ac source to the output ground. The negative half cycle operation can be divided into two modes (Mode III and Mode IV).
During mode III operation, the switch S2 is in on condition. When switch S2 turns on, inductor LB2 stores energy through the path Vin-LB2-S2-D3.

During mode IV operation, the switch S2 is in off condition. When switch S2 turns off, the energy stored in the inductor LB2 gets discharged and the current flows through diode D2, load RL, and returns to the mains through the diode D3.

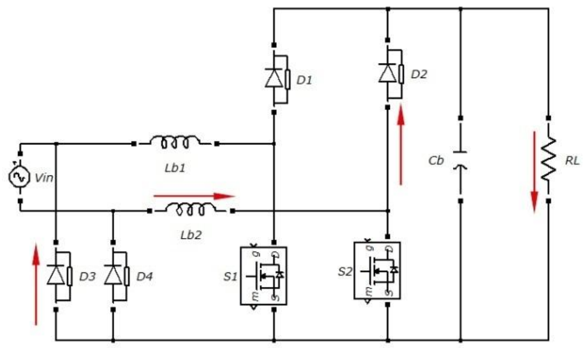

Fig. 3(d) Mode IV operation

IV. SIMULATION AND RESULTS

The computer simulation of conventional power factor correction boost rectifier and proposed bridgeless PFC boost converter are done using Matlab/Simulink and the results are presented.

4.1 Conventional PFC Boost Rectifier

Simulation circuit of conventional PFC boost rectifier is shown in Figure 4(a).

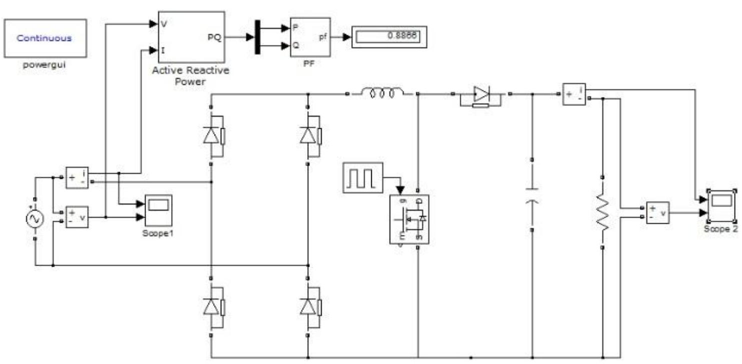

Fig.4 (a) Simulation of Boost Converter

Simulated line voltage and line current waveforms of conventional PFC boost rectifier operating at 230-Vrms line voltage are shown in figure 4 (b). The power factor is obtained as 0.8866. Figure 4(c) shows the FFT analysis of input current waveform.

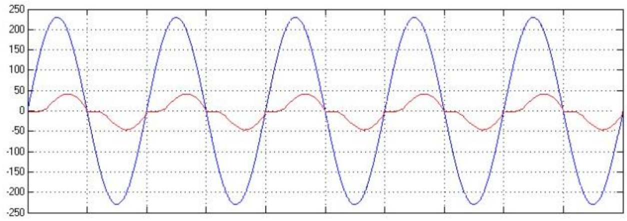

Fig 4(b) Input voltage and input current waveform

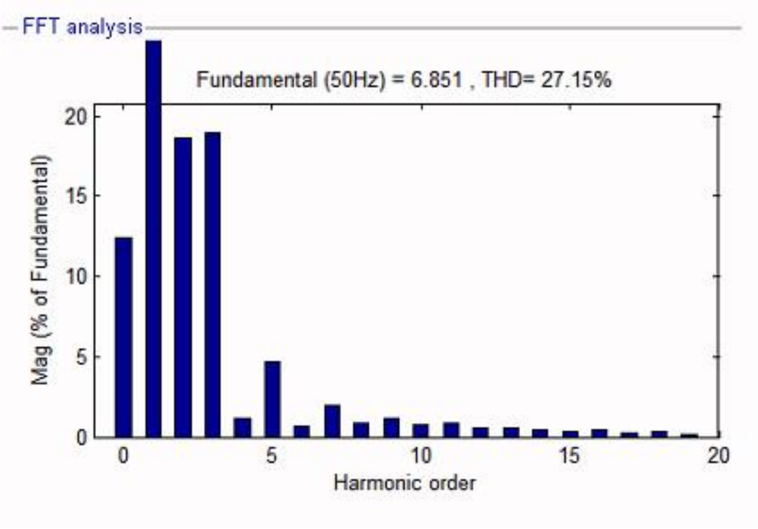

Fig. 4(c) FFT analysis of input current waveform

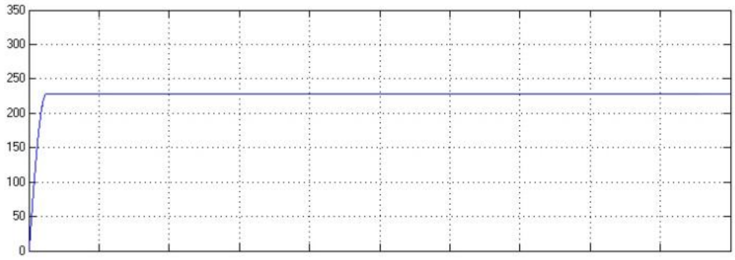

Fig. 4(d) Simulation of Bridgeless PFC Boost Converter

V. BRIDGELESS PFC BOOST CONVERTER

Simulation circuit of bridgeless PFC boost converter is shown in Fig.4 (d). The controlled switch implemented is the power MOSFET which has inherently slow body diode.

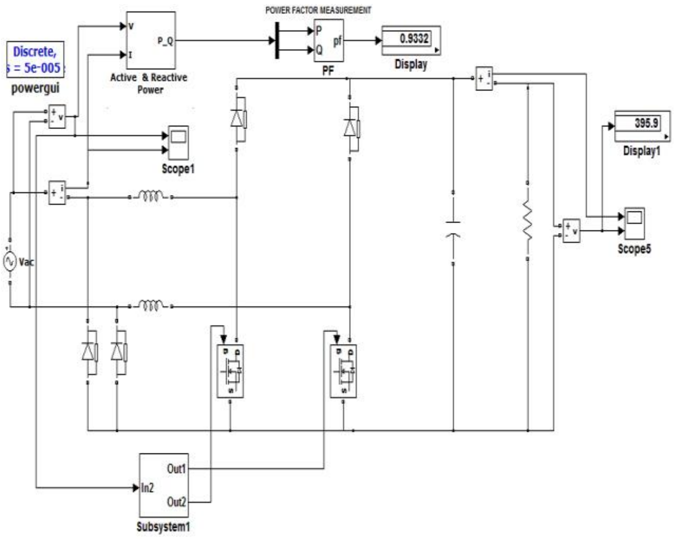

Fig 4 (e) Input voltage and input current waveform

Simulated line voltage and line current waveforms of bridgeless PFC boost rectifier operating at 230-Vrms line voltage are shown in figure 4 (e). The output voltage waveform is shown in figure 4 (f). FFT analysis of input current waveform is shown in figure 4(f). The THD percentage obtained in the simulation is <10% and the power factor is obtained as 0.9332

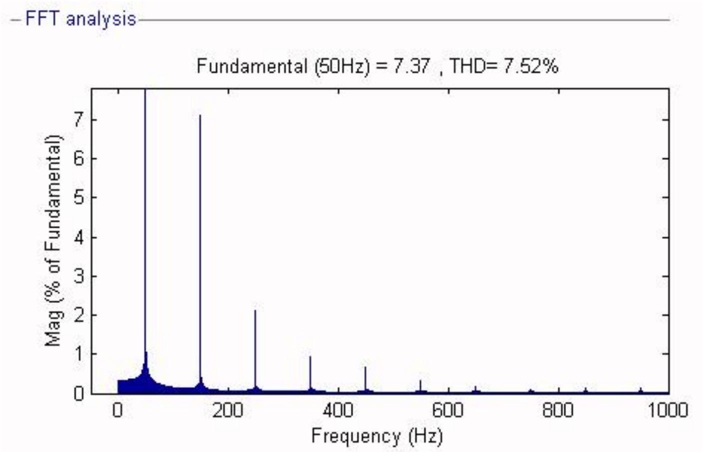

Fig. 4(f) Output voltage waveform

VI. CONCLUSIONS

A single-phase Bridgeless PFC Boost Converter is modeled and simulated using Matlab. Compared to the conventional PFC boost converter, the bridgeless PFC boost converter, also called the dual-boost PFC rectifiers, generally, improves the efficiency of the front end PFC stage by eliminating one diode forward-voltage drop in the line-current path. The Bridgeless PFC Boost Converter provides a good solution to implement low cost high power factor AC–DC converters with fast output regulation.

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