Power Factor Correction Using Bridgeless AC-DC Boost Converter

Prakash Udgire

IETE and ISTE Member, Associate Professor in EEE Department, Guru Nanak Dev. Engineering College, BIDAR, Karnataka

Abstract- **Nowadays electronic equipment such as computers, televisions, audio sets and others they need to require dc power supply. Power supplies make the load compatible with its power sources. The presence of nonlinear loads result 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.**

Index Terms-**Power factor correction (PFC), Conventional boost converter (CBC), Bridgeless PFC boost converter (BPFCBC), 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 & 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 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 nonlinearity 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 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 for power factor 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 necessary to deal with the problem of heat dissipation in limited surface area.

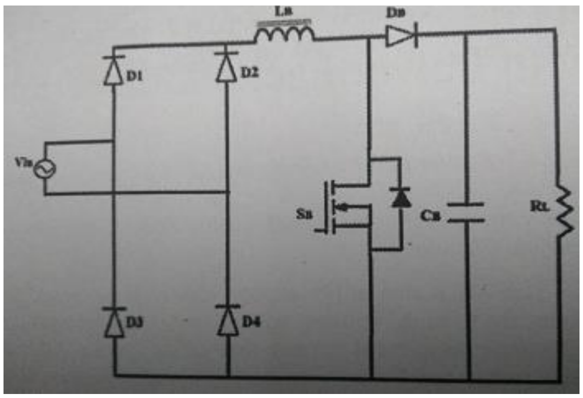

Fig. 1 Conventional PFC boost converter.

III. BRIDGELESS PFC BOOST CONVERTER

The bridgeless PFC booster converter is shown in figure 2. From a functional point of view, the circuit is similar to the common boost converter. In the conventional boost topology, current flows through two of the bridge diodes in series, whereas, in the bridgeless power factor correction configuration, current flows through only one diode and the return path is provided by power MOSFET.

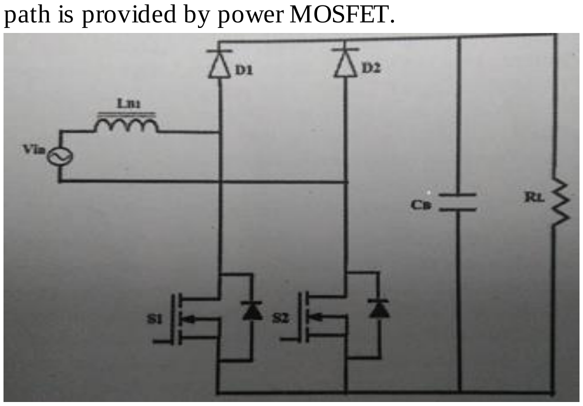

Fig. 2 Bridgeless PFC power converter

When the AC input voltage goes Positive, the gate of SI is driven high and current flows from the input through the inductor LB, storing energy. When SI turns off energy stored in the inductor gets discharged and the current flows through diode Dl, through the load and returns through the body diode of switch S2. During the negative half cycle, switch S2 is operated. When switch S2 turns on, current flows through the inductor, storing energy.

When S2 turns off, energy stored in the conductor is released and the current flows through D2, through the load and back to the mains through the body diode of switch S1.

Thus, in each half line cycle, one of the MOSFET operates as an active switch and the and the other one acts as a diode. The difference between bridgeless PFC and conventional PFC is that in bridgeless PFC converter the inductor current flows through only two semiconductor devices, but in conventional PFC circuit the inductor current flows through only three semiconductor devices. The two slow diodes of the conventional PFC converter are replaced by one MOSFET body diode in bridgeless PFC converter. Since both the circuits operates as a boost DC/DC converter, the switching loss of the conductor are same. Thus the efficiency improvement in bridgeless PFC converter relies on the conduction loss difference between the two slow diodes and the body diode of the MOSFET. The bridgeless PFC converter also reduces the total components count as compared to a conventional PFC converter.

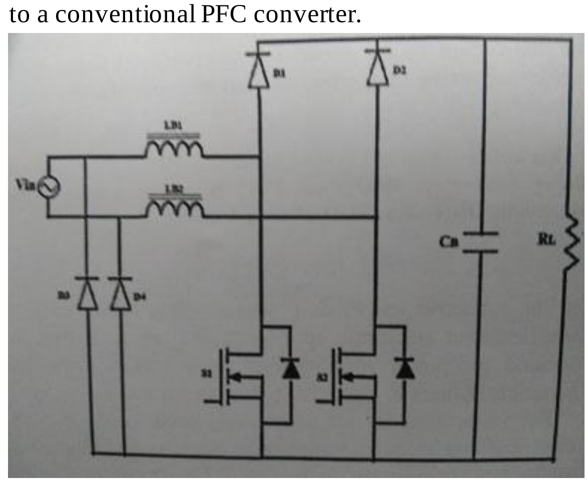
Fig. 3 Proposed bridgeless PFC boost converter.

To reduce the common mode noise, the bridgeless PFC boost rectifier is modified so that it always provide a low frequency (LF) path between the ac source and the positive or negative terminal of the output. In Fig 3, in addition to diodes D3 and D4, which are slow recovery diodes, a second inductor is also added. Inductor LB1 operates during positive half cycle and inductor LB2 operates during negative half cycle.

In bridgeless PFC boost rectifiers, the switches S1 and S2 can be driven with the same PWM signal. This simplifies the implementation of the control circuit.

The main drawback of the bridgeless PFC boost converter in Fig3 is that it requires two inductors. However two conductors compared to a single inductor provide better thermal performance.

A. Operation of bridgeless PFC boost converter

The operation of bridgeless PF correction boost converter can be divided into four modes. Mode 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.

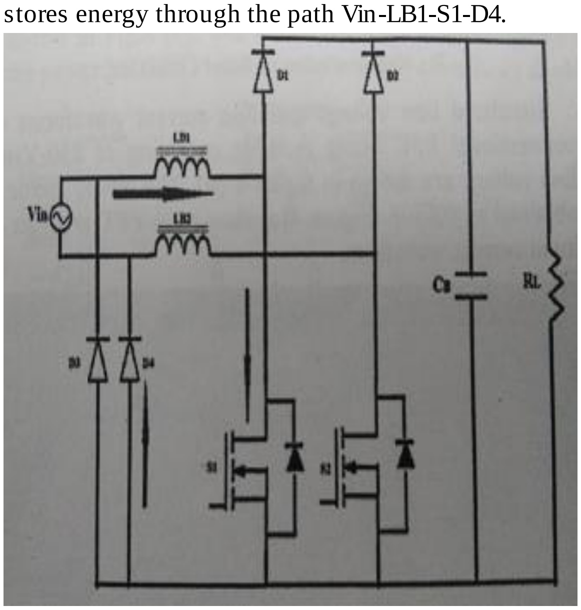

Fig. 3a Mode I Operation.

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.

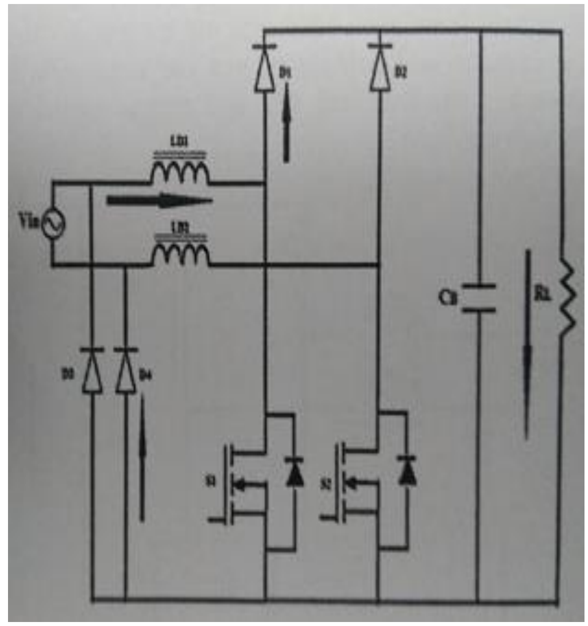

Fig. 3b Mode II operation.

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.

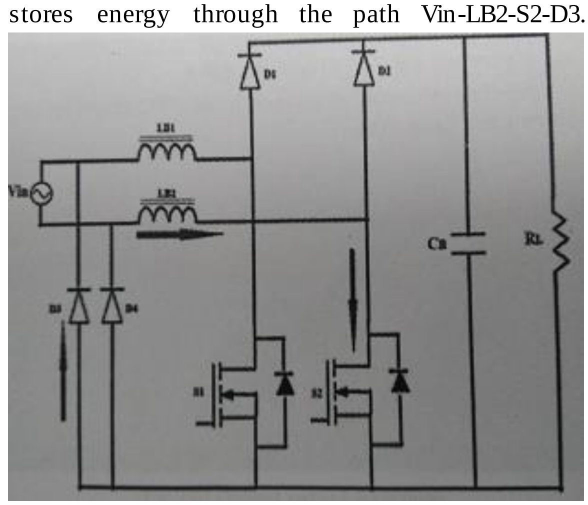

Fig. 3c Mode III operation.

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.

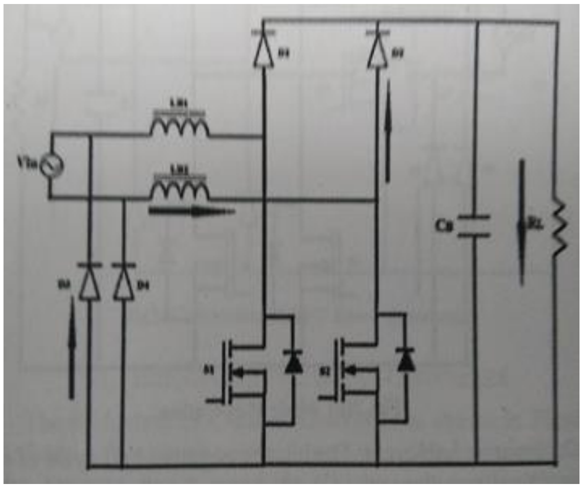

Fig. 3d Mode IV operation.

IV. SIMULATION RESULTS

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

A. Conventional PFC boost rectifier.

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

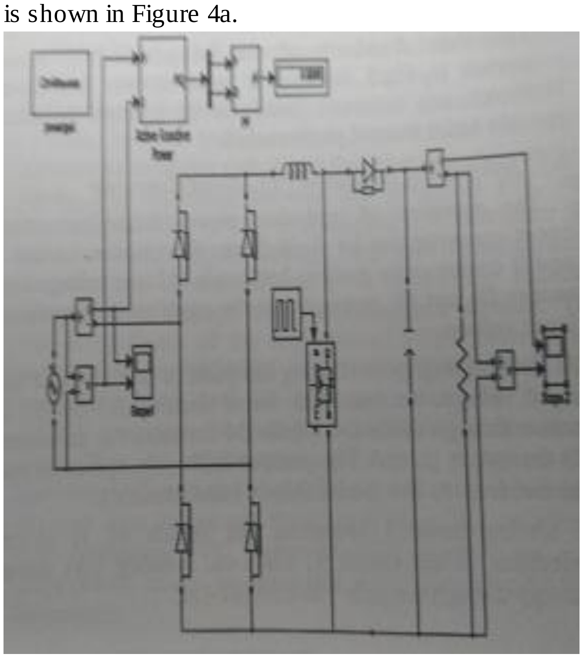

Fig. 4a Simulation of boost converter

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

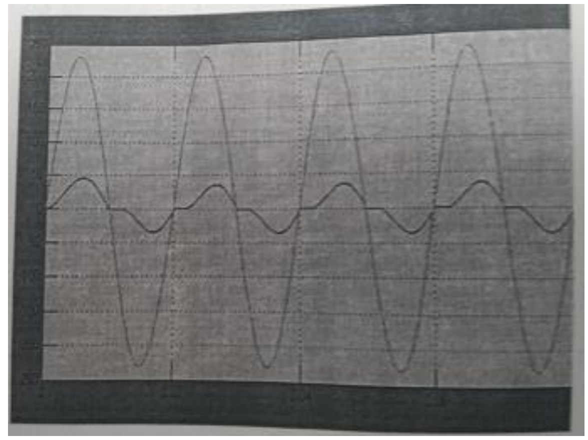

Fig. 4b Input voltage and input current waveform.

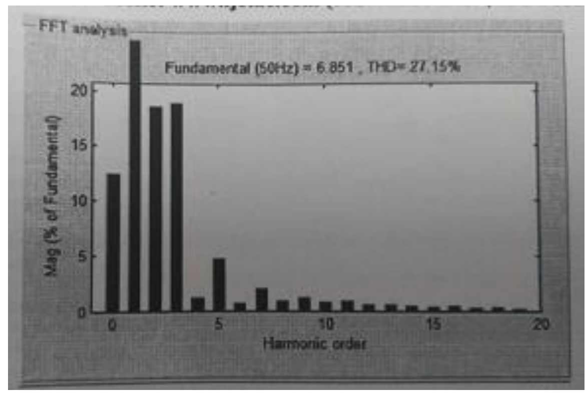

Fig. 4c FFT analysis of input current waveform.

B. Bridgeless PFC boost converter.

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

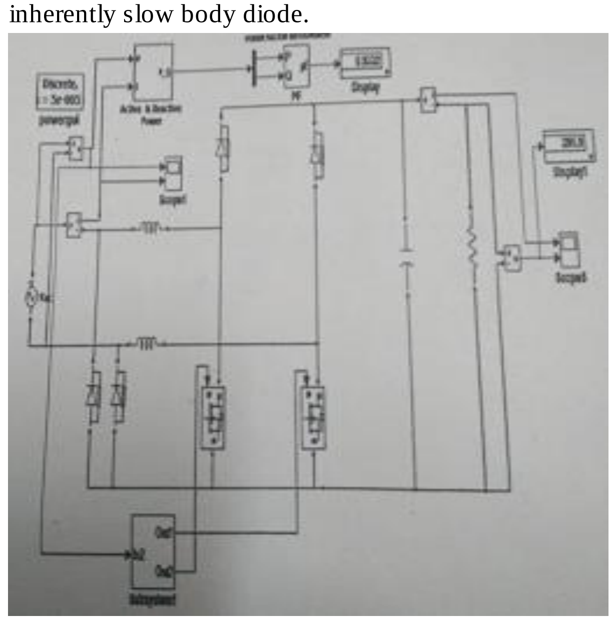

Fig. 4d Simulation of bridgeless PFC boost converter.

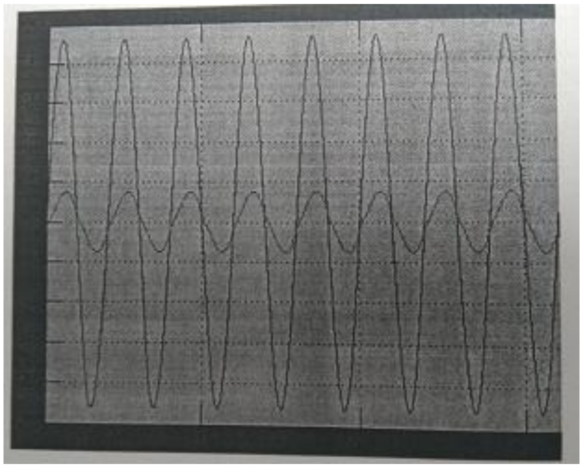

Fig. 4e Input voltage and input current waveform.

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

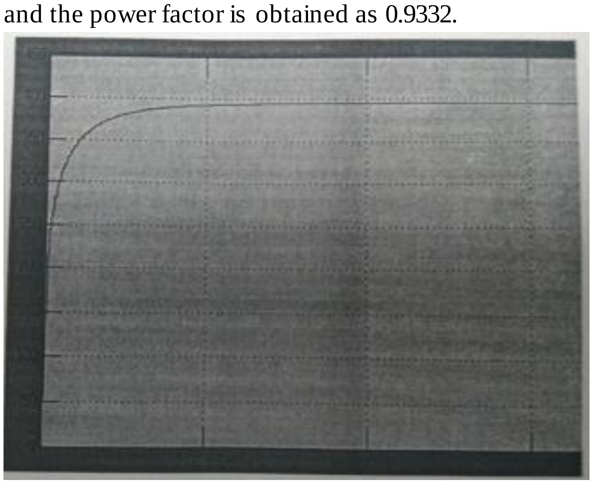

Fig. 4f Output voltage waveform.

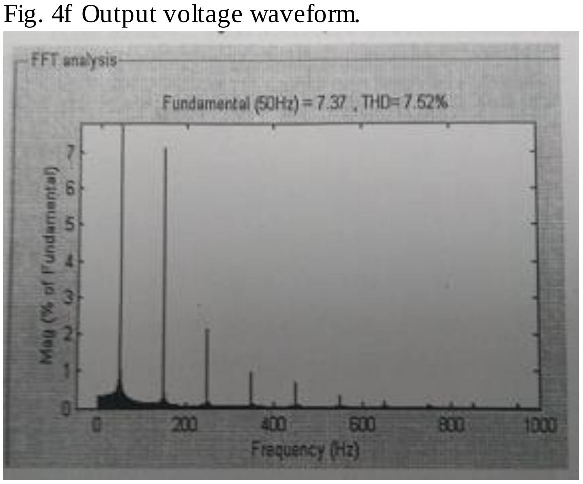

Fig. 4g FFT analysis of input current waveform.

V. CONCLUSION

A single phase bridgeless PFC boost converter is modeled and simulated using Mat lab. 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 converter with fast output regulation.

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