Control of DC Drive by Bridgeless PFC Boost Topology

M. Gopinath and S. Ramareddy

Abstract—**This paper deals with the simulation of Bridgeless PFC boost Converter fed DC drive. The Bridgeless circuit is analyzed, designed and simulated with motor load. Conventional boost PFC suffers from the high conduction loss in the input rectifier-bridge. Higher efficiency can be achieved by using the bridgeless boost topology. In this paper, a systematic review of bridgeless power factor correction (PFC) boost rectifiers, also called dual boost PFC rectifiers, is presented. The circuit has advantages like reduced conduction loss, reduced harmonics and improved power factor.**

Index Terms—**Boost converter, bridgeless, power factor correction (PFC).**

I. Introduction

Recently, in an effort to improve the efficiency of the front-end PFC rectifiers, many power supply manufacturers and some semiconductor companies have started looking into bridgeless PFC circuit topologies. Generally, the bridgeless PFC topologies, also referred to as dual boost PFC rectifiers, may reduce the conduction loss by reducing the number of semiconductor components in the line current path. The bridgeless PFC boost implementations have received more attention. In each circuit, the boost converter is implemented by replacing a pair of bridge rectifiers with switches and employing an ac-side boost inductor. With a bridgeless topology, one rectifier is eliminated from the line-current path, which minimizes the conduction loss. In this paper, a systematic review of the bridgeless PFC boost rectifier implementations that have received the most attention is presented. The implementations do not suffer from the high common-mode noise problem. The block diagram of bridgeless PFC boost converter fed dc drives is shown in Fig. 01.

II. Review of Bridgeless PFC Boost Rectifiers

Bridgeless boost PFC is a concept that has been long on promise for many years, but has not reached mainstream acceptance. Issues with EMI, robustness and the complexity of early configurations have stymied efforts to realize the bridgeless boost PFC converter's potential. Furthermore, improvements in components used in standard PFC boost converters have resulted in efficiency gains that did not justify the extra cost and complexity of the bridgeless configuration. And while bridgeless PFC has been viewed as a potentially useful technique to improve low line input efficiency, it is not certain that is where the demand for improvement lies today.

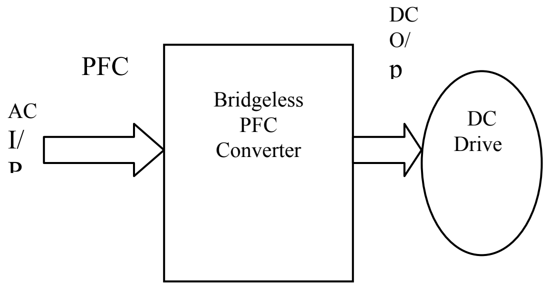

Fig. 01. Block diagram of Bridgeless PFC converter Fed Dc Drive

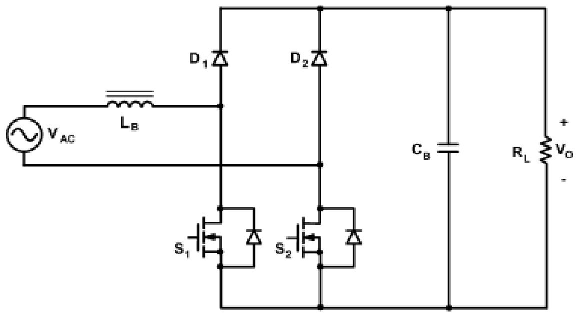

Fig. 02. Basic Bridgeless topology

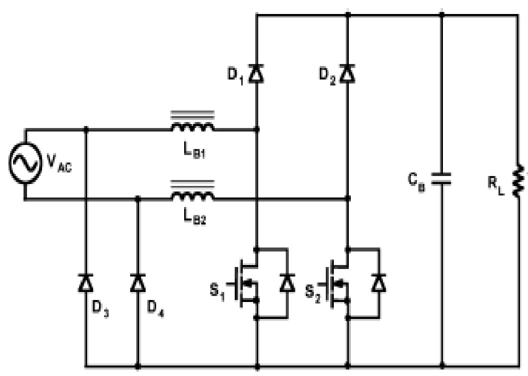

Fig. 03. Bridgeless PFC boost rectifier with reduced CMI

The basic topology of the bridgeless PFC boost rectifier is shown in Fig. 02. Compared to the conventional PFC boost rectifier, one diode is eliminated from the line-current path, so that the line current simultaneously flows through only two semiconductors, resulting in reduced conduction losses. However, the bridgeless PFC boost rectifier has significantly larger common-mode noise than the conventional PFC boost rectifier. In fact, in the conventional PFC boost rectifier, the output ground is always connected to the ac source through the full-bridge rectifier (slow-recovery diodes D3 and D4); whereas, in the bridgeless PFC boost rectifier, the output ground is connected to the ac source only during a positive half-line cycle, through the body diode of switch S2, while during a negative half-line cycle the output ground is

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pulsating relative to the ac source with a high frequency (HF) and with an amplitude equal to the output voltage. This HF pulsating voltage source charges and discharges the equivalent parasitic capacitance between the output ground and the ac line ground, resulting in a significantly increased common-mode noise. To reduce the common-mode noise of the bridgeless PFC boost rectifier in Fig. 02, i.e., to make it similar to that of the conventional PFC boost rectifier, the topology of the bridgeless PFC boost rectifier needs to be modified always to provide a low-frequency (LF) path between the ac source and the positive or negative terminal of the output. The modification of the basic bridgeless PFC boost rectifier is implemented by adding two diodes, D3 and D4. In addition, the common-source node of switches S1 and S2 is disconnected from the output ground and a second inductor is also added, resulting in two dc/dc boost circuits, one for each half-line cycle. Hence the reduced common-mode noise of the bridgeless PFC boost rectifier is shown in Fig. 03.

III. Converter FED DC Drives

Converter-controlled electrical machine drives are very important in modern industrial applications. Some examples in the high-power range are metal rolling mills, cement mills, and gas line compressors. In the medium-power range are textile mills, paper mills, and subway car propulsion. Machine tools and computer peripherals are examples of converter-controlled electrical machine drive applications in the low-power range. The converter normally provides a variable-voltage dc power source for a dc motor drive and a variable-frequency, variable-voltage ac power source for an ac motor drive. The drive system efficiency is high because the converter operates in switching mode using power semiconductor devices. The primary control variable of the machine may be torque, speed, or position, or the converter can operate as a solid-state starter of the machine. The recent evolution of high-frequency power semiconductor devices and high-density and economical microelectronic chips, coupled with converter and control technology developments, is providing a tremendous boost in the applications of drives. The speed of a dc motor can be controlled by controlling the dc voltage across its armature terminals. The machine can be a permanent magnet or wound field type. The wound field type permits variation and reversal of field and is normally preferred in large power machines. In this paper Bridgeless PFC converter is used to control the dc drive under no load and load conditions.

IV. Simulation Results

Simulation is done using Mat lab Simulink and the results are presented. The conventional boost topology is the most efficient for PFC applications. It uses a dedicated diode bridge to rectify the AC input voltage to DC, which is then followed by the boost section. This approach is good for a low to medium power range. As the power level increases, the diode bridge begins to become an important part of the application and it is necessary for the designer to deal with the problem of how to dissipate the heat in limited surface area.

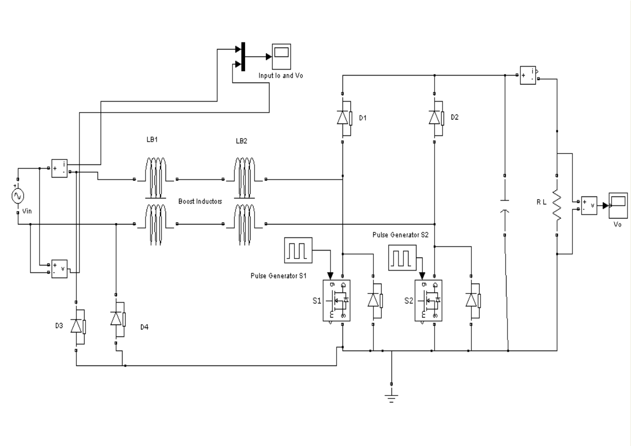

Fig. 04. Bridgeless PFC boost Circuit

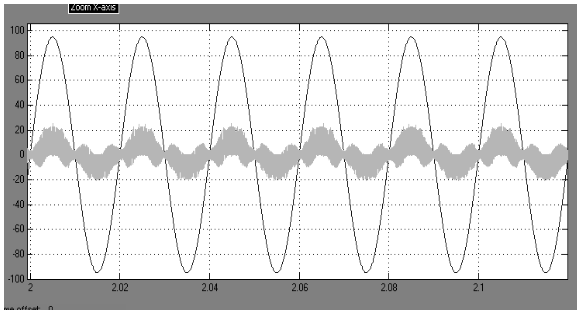

Fig. 05. Input voltage & current

The dissipated power is important from an efficiency point of view. The bridgeless configuration topology presented in this paper avoids the need for the rectifier input bridge yet maintains the classic boost topology. This is easily done by making use of the intrinsic body diode connected between drain and source of Power MOS switches. A simplified simulation of the bridgeless PFC configuration is shown in Fig. 04. The circuit shown from a functional point of view is similar to the common boost converter. In the traditional topology current flows through two of the bridge diodes in series. In the bridgeless PFC configuration, current flows through only one diode with the Power MOS providing the return path. The input voltage and current wave form is shown in Fig. 05. The power factor is improved and the measured value is 0.9982. The corresponding output voltage is boosted to 400 volts.

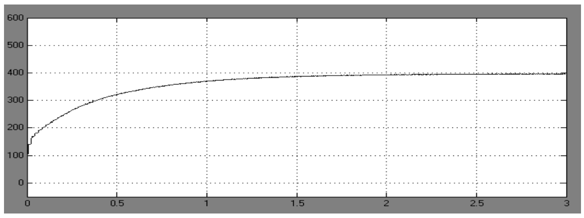

Fig. 06. DC output voltage

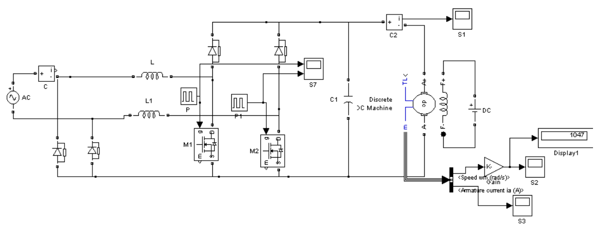

Fig. 07. Proposed converter fed dc drives

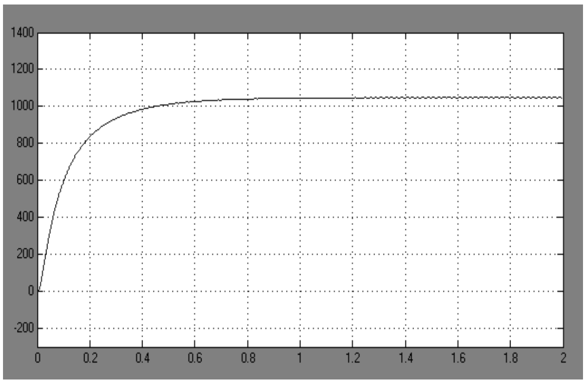

Fig. 08. Speed of motor at no load

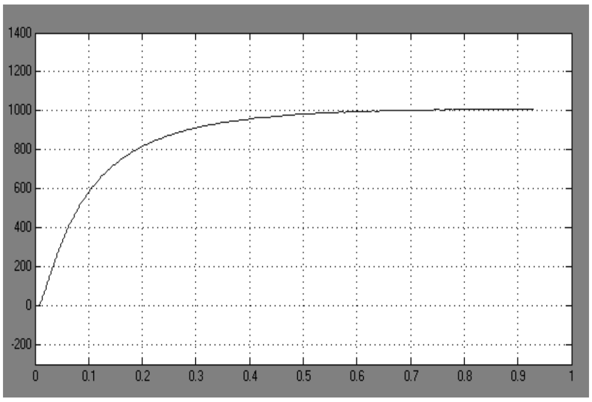

Fig. 09. Speed of motor at T=1Nm

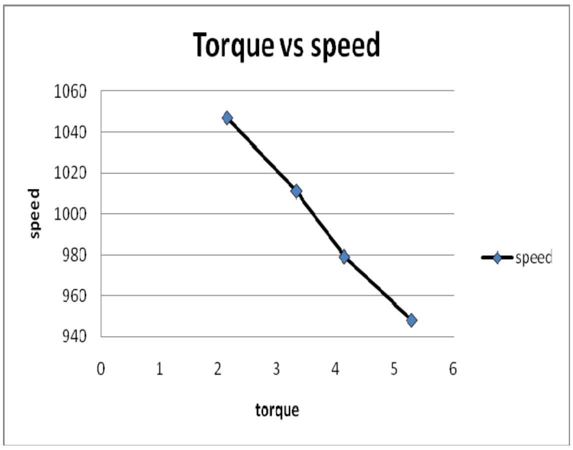

Fig. 10. Speed – torque characteristics of motor

The Fig. 06. Shows the output voltage. The proposed converter is fed to a separately excited dc drives. The simulation circuit is shown in Fig. 07. The drive is operated under two conditions. One at no load and at loaded condition. The speed of armature is above 1000 rpm under no load condition, it get reduced when it is operated at load condition. The results are observed from the Fig. 08. and Fig. 09. The speed torque curve of the dc motor is shown in Fig.10. The result implies that the speed value decreases with increase in torque.

V. Conclusion

Bridgeless PFC Converter fed dc drives is modeled and simulated using Mat lab. The simulation studies indicate that the power factor is nearly unity by employing the Bridgeless boost converter. This converter has advantages like reduced hardware, high performance and improved power factor. The speed torque cure indicates the mechanical characteristic of dc drives. The smooth speed control is possible with this bridgeless converter. The simulation results are in line with the predictions. The hardware implementation will be done in future.

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