SIMULATION OF CLOSED LOOP CONTROLLED BRIDGELESS PFC BOOST CONVERTER

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ABSTRACT:

Conventional boost PFC converter 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, digital simulation of bridgeless PFC boost rectifiers, also called dual boost PFC rectifiers, is presented. Performance comparison between the conventional PFC boost rectifier and the bridgeless PFC boost rectifier is performed. A Closed loop controlled bridgeless PFC converter is modeled and simulated.

Keywords: *PFC, Bridgeless Rectifier, Converter Conduction Loss.*

I- INTRODUCTION

In recent years, there have been increasing demands for high power factor and low total harmonic distortion (THD) in the current drawn from the utility. With the stringent requirements of power quality [1], power-factor correction (PFC) has been an active research topic in power electronics, and significant efforts have been made on the developments of the PFC converters [2]. In general, the continuous-conduction mode (CCM) boost topology has been widely used as a PFC converter because of its simplicity and high power capability. It can be used with the universal input voltage range.

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. So far, a number of bridgeless PFC boost rectifier implementations and their variations have been proposed.

In this paper, a systematic review of the bridgeless PFC boost rectifier implementations that have received the most attention is presented. Performance comparison between the conventional PFC boost rectifier and a representative member of the bridgeless

PFC boost rectifier family is performed. Loss analysis for both continuous- conduction mode (CCM) and discontinuous-conduction mode (DCM)/CCM boundary operations are provided.

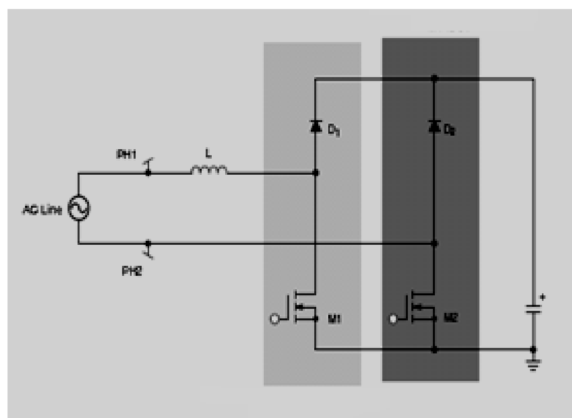


Fig 1: Bridgeless PFC circuit

II- BRIDGELESS PFC BOOST CONVERTER

The bridgeless PFC circuit is shown in Figure 1. The boost inductor is split and located at the AC side to construct the boost structure. In this first half line cycle, MOSFET M1 and boost diode D1, together with the boost inductor construct a boost DC/DC converter. Meanwhile, MOSFET M2 is operating as a simple diode. The input current is controlled by the boost converter and following the input voltage. During the other half line cycle, circuit operation as the same way. Thus, in each half line cycle, one of the MOSFET operates as active switch and the other one operates as a diode: both the MOSFET's can be driven by the same signal. The difference between the bridgeless PFC and conventional PFC is summarized in Table 1. Comparing the conduction path of these two circuits, at every moment, bridgeless PFC inductor current only goes through two semiconductor devices, but inductor current goes through three semiconductor devices for the conventional PFC circuit. The conventional method is shown in Figure 2.

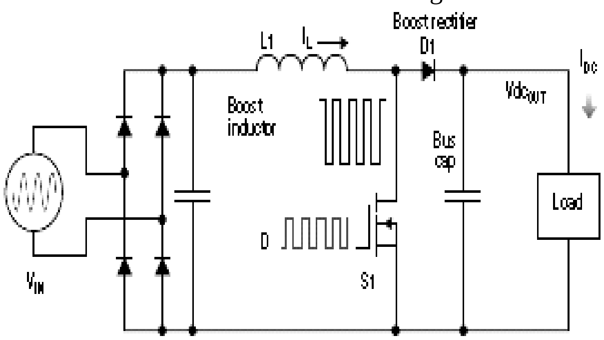


Fig 2: Conventional PFC circuit

PFC Converter	Slow diode	Fast Diode	MOSFET	Conduction Path On/(Off)
Conventional PFC	4	1	1	2 slow diode, 1MOSFET/ (2 slow diode, 1 fast diode)
Bridgeless PFC	0	2	2	1 body diode, 1 MOSFET/ (1 MOSFET body diode, 1diode)

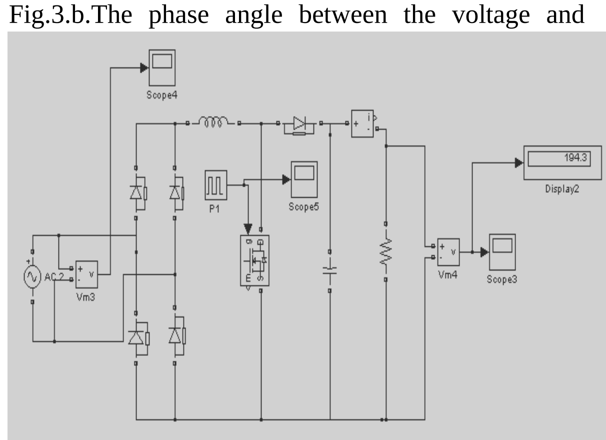
Table I – Summary of differences between conventional PFC and bridgeless PFC

As shown in Table 1, the bridgeless PFC uses one MOSFET body diode to replace the two slow diodes of the conventional PFC. Since both the circuits operating as a boost DC/DC converter, the switching loss should be the same. Thus the efficiency improvement relies on the conduction loss difference between the two slow diodes and the body diode of the MOSFET. Besides, comparing with the conventional PFC, the bridgeless PFC not only reduces conduction loss, but also reduces the total components count.

To reduce the rectifier bridge conduction loss, different topologies have been developed. Among these topologies, the bridgeless boost doesn't require range switch, shows both the simplicity and high performance. High performance single phase AC to DC rectifier with input power factor correction is given by [3]. A new ZCS quasi-resonant unity power factor is proposed by [4]. ZVS-PWM unity power factor rectifier is given in [5]. Single phase AC to DC rectifier with input power factor correction is given in [6]. Semi resonant high power factor rectifier is presented by [7]. A power-factor controller for PWM rectifier is presented in [8]. The above literature does not deal with the modeling of closed loop controlled bridgeless PFC converter. The aim of this work is to develop a Simulink model for closed loop controlled PFC converter.

III- SIMULATION RESULTS

Simulation is done using Matlab Simulink and the results are presented. The conventional boost converter is shown in Fig 3.a.The corresponding AC input voltage and current waveforms are shown in Fig.3.b.The phase angle between the voltage and



current is higher. Driving pulse for the MOSFET is shown in Fig.3.C. DC output current is shown in Fig.3.d. DC output voltage is shown in Fig.3.e.

Fig 3.a: Conventional Boost Converter

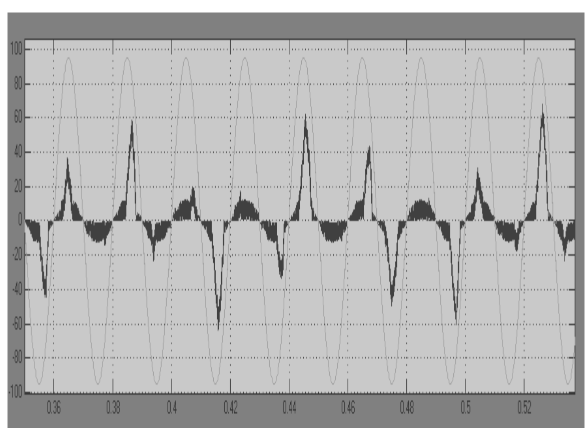


Fig 3.b: AC input Voltage and current

Modified Boost converter is shown in Fig.4.a. It is assumed that a controlled switch is implemented as the power MOSFET with its inherently slow body diode. Voltage across the MOSFET's 1& 2 are shown in Figs 4.b. and 4.c. respectively. Ac input voltage and current are shown in Fig 4.d.It can be seen that the current and voltage are almost in phase. DC output current and output voltage are shown in Figs 4.e and 4.f respectively. Variation of output voltage with input voltage is shown in Fig 4.g.

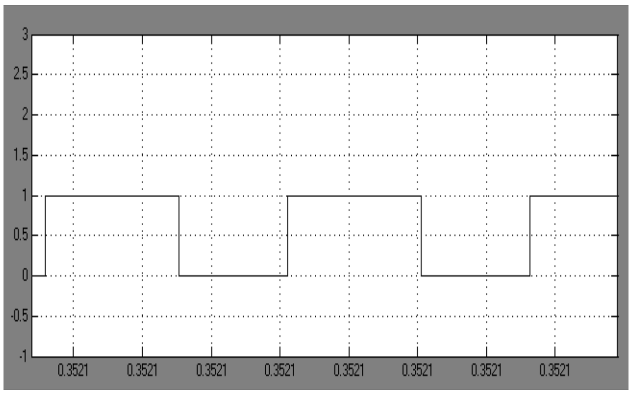


Fig 3.c: Driving pulse for S1

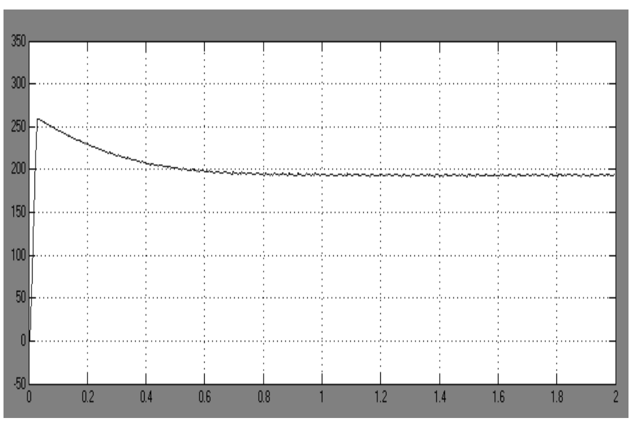


Fig 3.d: DC output current

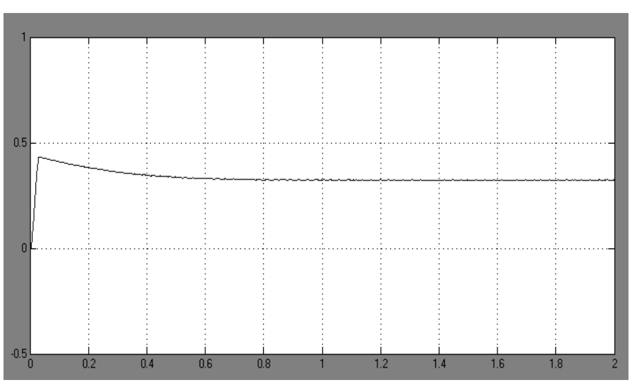


Fig 3.e: DC output Voltage

Open loop controlled boost converter circuit is shown in Fig 5.a. Step rise in input voltage is shown in Fig 5.b. DC output voltage also increases as shown in Fig 5.c. Closed loop system is shown in Fig 6.a. Output voltage is sensed and it is compared with a reference voltage. The error is processed through a PI controller. Step rise in input voltage for closed loop system is shown in Fig 6.b.The output of the pulse generator controls the output voltage till it reaches the set value. It can be seen that the DC voltage reaches the set value as shown in Fig 6.c.

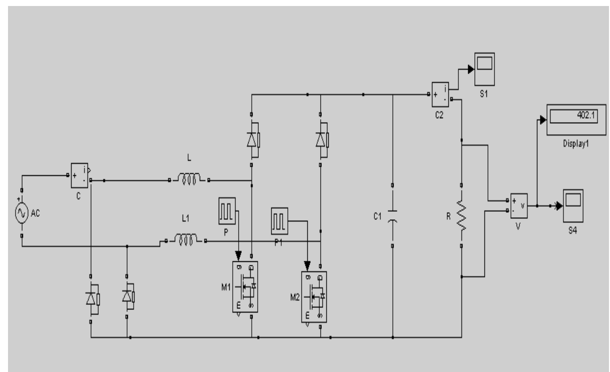


Fig 4.a: Modified Boost converter

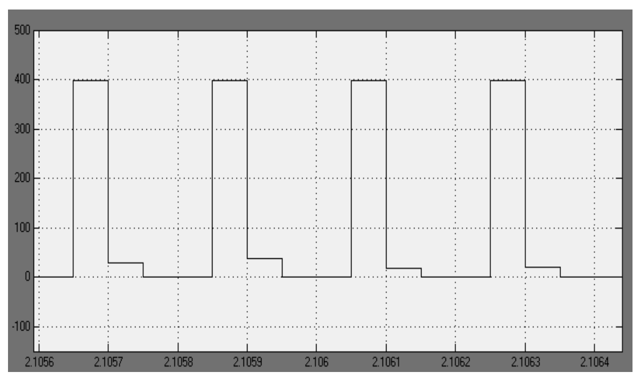


Fig 4.b: Voltage across switch-1

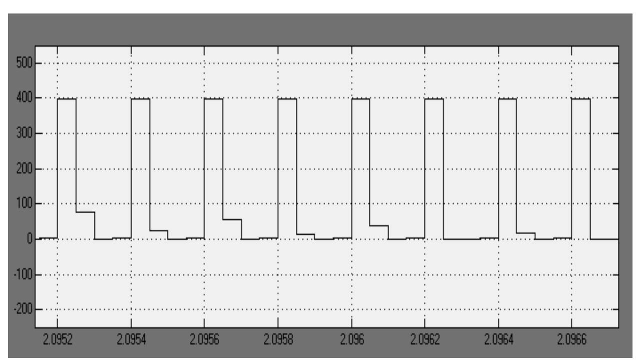


Fig 4.c: Voltage across switch-2

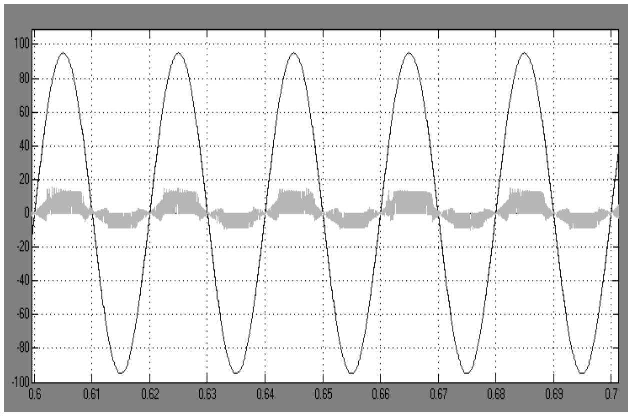


Fig 4.d: AC input voltage and current \

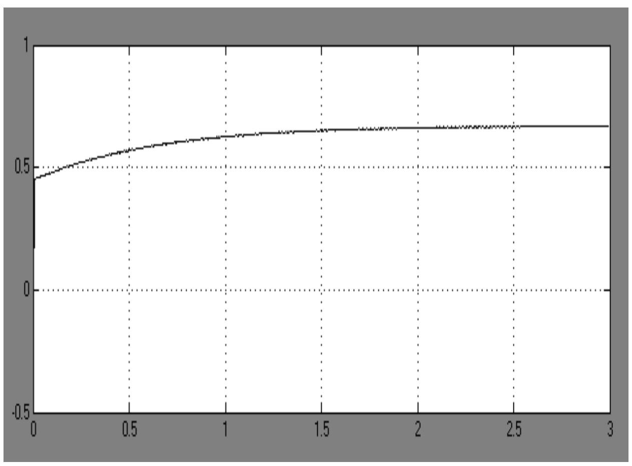


Fig 4.e: DC output current

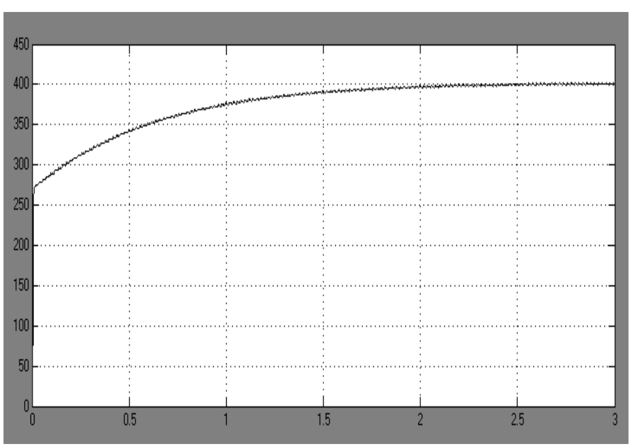


Fig 4.f: DC output voltage

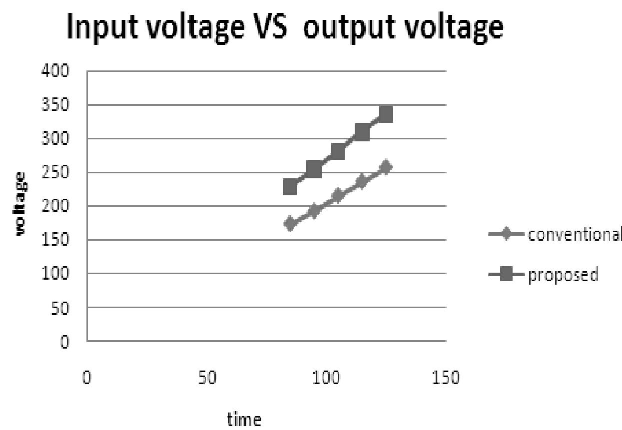


Fig: 4.g Input voltage vs. Output voltage

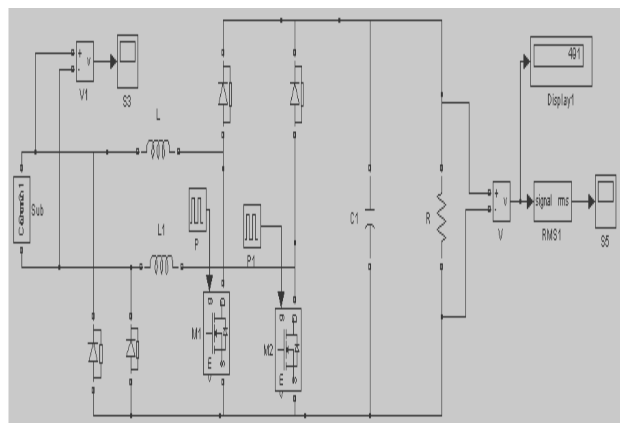


Fig 5.a: open loop controlled boost converter.

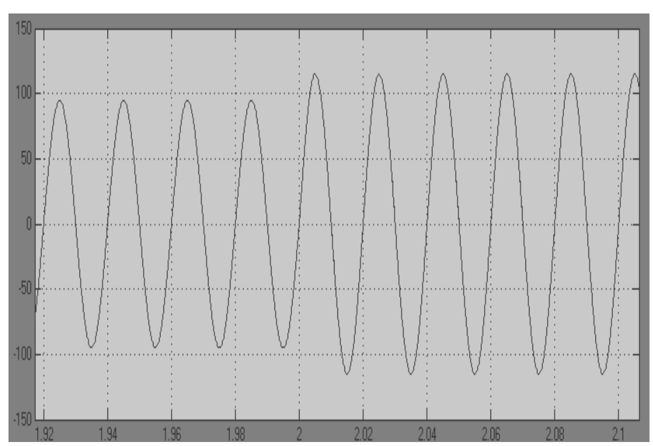


Fig 5.b: Input voltage.

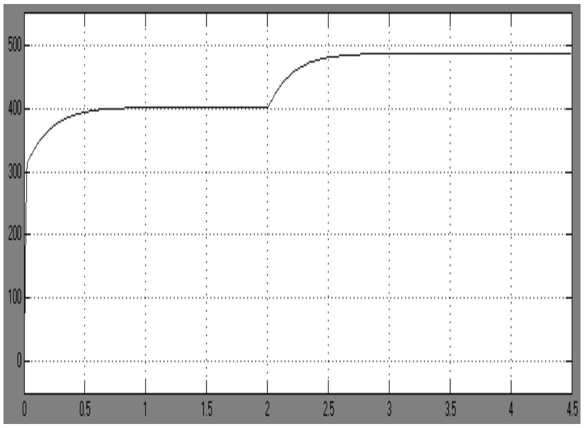


Fig 5.c: DC output voltage.

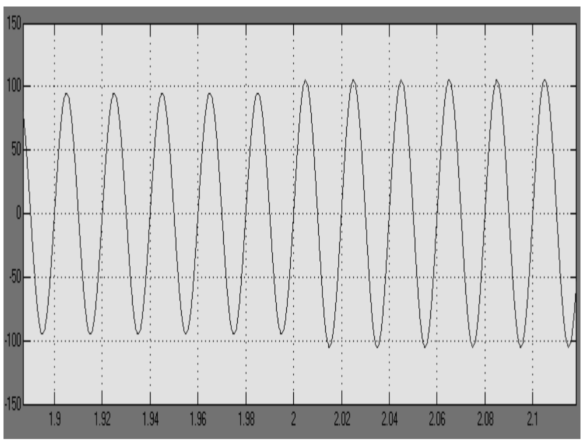


Fig 6.b: Input Voltage.

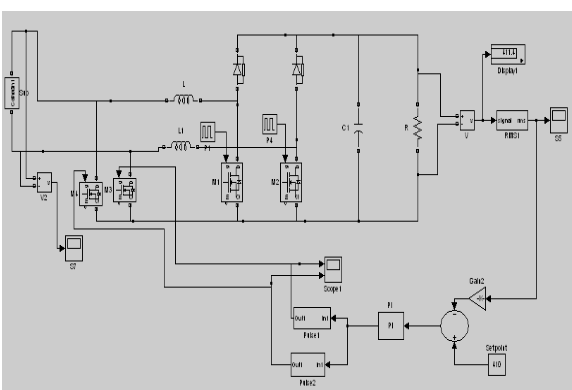


Fig 6.a: Closed loop controlled boost converter.

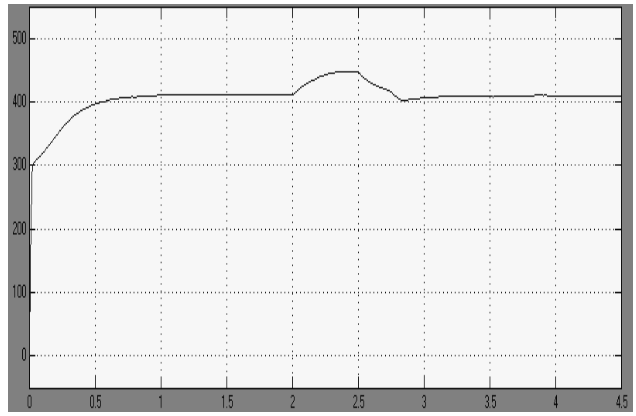


Fig 6.c: Output Voltage

IV -CONCLUSION

Bridgeless PFC Converter is modeled and simulated using Matlab. Open loop and closed loop models are developed and they are used successfully for simulation. The simulation studies indicate that the power factor is nearly unity by employing the modified boost converter. This converter has advantages like reduced hardware, high performance and improved power factor. The simulation results are in line with the predictions. This work has covered the simulation of open loop and closed loop controlled PFC converter. The hardware implementation will be done in future.

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