ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Analysis of Bridgeless PFC Rectifier using MATLAB-SIMULINK

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ABSTRACT: This paper analyses a bridgeless PFC converter using MATLAB-SIMULINK . The PFC Converter used in this paper works on discontinuous mode, active power factor correction (PFC) techniques are becoming necessary for the electronic equipment to meet harmonic regulations and standards . Here a single phase PFC rectifier is analysed , it has less number of components count, higher power density and less conduction losses . Open loop and closed loop simulation results are provided to verify the performance.

KEYWORDS: Bridgeless resonant PFC rectifier , Power factor correction , Single phase rectifier ,Total harmonic distortion(THD).

I.INTRODUCTION

According to the demand on high efficiency and low harmonic pollution, the active power factor correction (PFC) circuits are commonly employed in ac-dc converters and switched-mode power supplies. Generally, these converters include a full-bridge diode rectifier on an input current path so that conduction losses on the full-bridge diode occur and it will be worse especially at the low line. To overcome this problem, bridgeless converters have recently been introduced to reduce or eliminate the full-bridge rectifier, and hence their conduction losses. Most of the conventional proposed bridgeless PFC converters have at least one of the following drawbacks- high components count, components are not fully utilized over whole ac-line cycle, complex control, lack of galvanic isolation due to the floating ground, some topologies require additional diodes and/or capacitors to minimize EMI.

In this paper, the converter operate in resonant mode to obtain an automatic PFC close to unity in a simple manner. The resonant mode operation have zero-current turn-on in the active power switches, zero-current turn-off in the output diode and this reduces the complexity of the control circuitry. The advantages of the converter is less number of components, low switching losses, high efficiency etc. Open loop simulation and closed loop simulation are provided in this report for performance evaluation.

Next section discusses the principle of operation of proposed Bridgeless PFC converter and also its modes of operation. Third section deals with the closed loop and open loop simulation diagrams and results. Fourth section concludes the topic.

II.LITEARTURE SURVEY

Power factor correction is important in switched mode power supplies. Most of the PFC rectifier include a boost/buck–boost topology converter at their front end due to its high power factor (PF) capability. The major disadvantage of the conventional PFC converters is its lower efficiency due to significant losses in the diode bridge. In order to reduce these problem, an efficient bridgeless PFC circuit topologies were developed..Bu t these bridgeless PFC topologies also have some following drawbacks like high components count, components are not fully utilized over whole ac-line cycle, complex control, dc output voltage is always higher than the peak input voltage, lack of galvanic isolation, and due to the floating ground, some topologies require additional diodes and/or capacitors to minimize EMI.

DOI: 10.15662/ijareeie.2015.0408027

In order to overcome most of these problems, bridgeless SEPIC PFC topology with reduced component count has been introduced in [5]. But this topology is still suffers from having at least two semiconductors in the current conduction path during each switching cycle. A novel single-phase soft-switched rectifier and minimal component count is presented in [4] , it is a zero current switch topology. This topology has reduced-component count, however, the load is floating with respect to the input. Compared with existing single-phase bridgeless topologies , the proposed topology has low component count, a single control signal, and non floating output.

III. PRINCIPLE OF OPERATION

A new bridgeless resonant pseudo boost PFC converter is shown in Fig. 1, it mainly consists of two power switches Q1 and Q2,these can be driven by the same control signal, which significantly simplifies the control circuitry. It has high-frequency input filter and it is inserted to filter the pulsating high frequency resonant inductor ripple L_1current.This converter contains a resonant capacitor C_1 and a high value capacitor Co across the load in order to maintain a constant output voltage. The proposed converters of Fig.1 are designed to operate in discontinuous-conduction mode (DCM) during the switch turn-on interval and in resonant mode during the switch turnoff intervals.

Mainly there are four modes of operation. Charging and discharging of the magnetizing inductance is described in these modes. due to the symmetry of the circuit, it is sufficient to analyze the circuit during the positive half-period of the ac-input voltage.

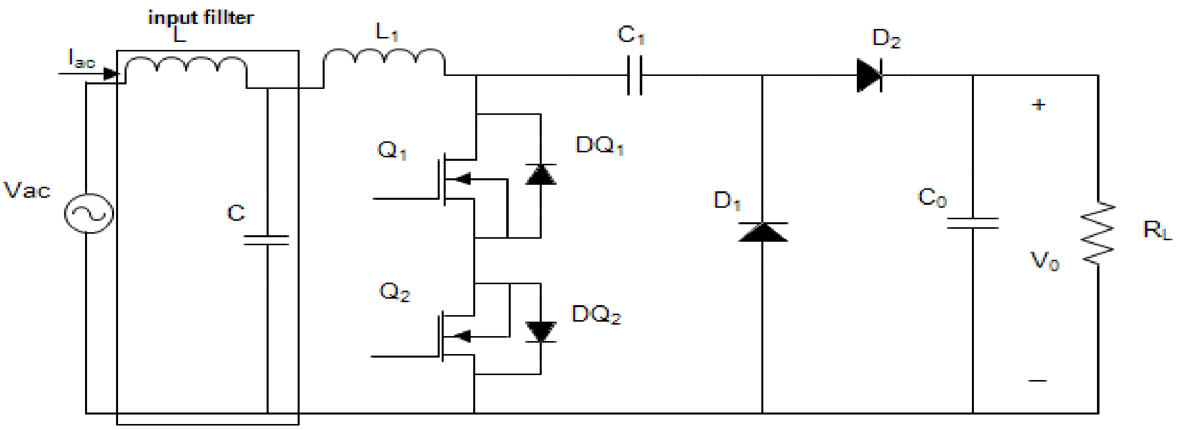

Fig. 1 Converter Circuit

1.1. Mode 1

Fig.2 shows the equivalent circuit for mode 1.

- Switch Q_1 is turned ON
- The body Diode of Q_2 is forward biased by the inductor current i_{L1}
- Diode D_1 is reverse biased by the voltage across C_1
- D_2 is reverse biased by the voltages V_{C1} + Vo
- Voltage across capacitor C_1 remains constant at voltage Vx

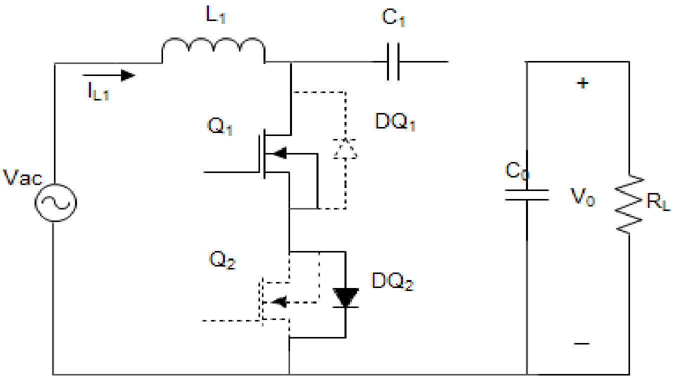

Fig. 2 Equivalent circuit of mode 1

1.2. Mode 2

Fig.3 shows the equivalent circuit diagram for mode 2.

- Switch Q1 is turned OFF
- Diode D_2 is turned ON simultaneously providing a path for the inductor currents i_{L1}
- Diode D_1 remains reverse biased during this interval.
- L_1 and $C_1$are excited by the input voltage Vac through diode D_2

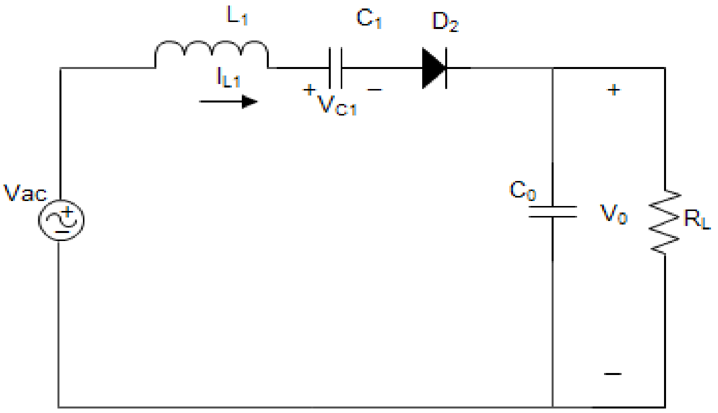

Fig. 3 Equivalent circuit of mode 2

1.3. Mode 3

Fig.4 shows the equivalent circuit diagram for mode 3

- Diode D_1 is forward biased to provide a path during the negative cycle of the resonating inductor current i_{L1}
- This stage ends when the inductor current reaches zero
- During this stage diode $D_1$is switched ON and OFF under zero current conditions

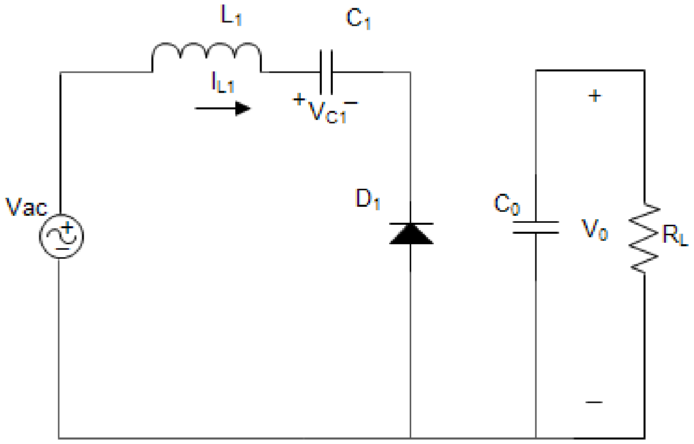

Fig. 4 Equivalent circuit of mode 3

1.4. Mode 4

Fig.5 shows the equivalent circuit diagram for mode 4

- During this stage all switches are in their off-state
- The inductor current is zero and the capacitor voltage remains constant ($V_{C1}= V_x$)

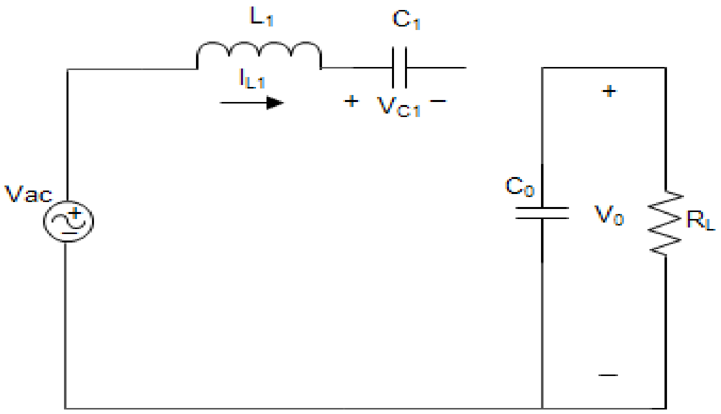

Fig. 5 Equivalent circuit of mode 4

IV. SIMULATION

Fig.6 shows the open loop simulation diagram of the converter. Switching pulses for the two switches are given from same pulse generator. The switching frequency is appropriately chosen in order to switch on Q_1 during positive half cycle and Q_2 during negative half cycle, and the parameters are chosen accordingly to obtain discontinuous mode. A large value capacitor is chosen in order to maintain a constant output voltage.

3.1. Simulation Parameters

fs = 50kHz
f = 50Hz
V_{AC} = 85Vrms
L = 1mH
C = 1μF
L1 = 100μH
Co = 470μF
Ro = 500Ω
Vo = 240V

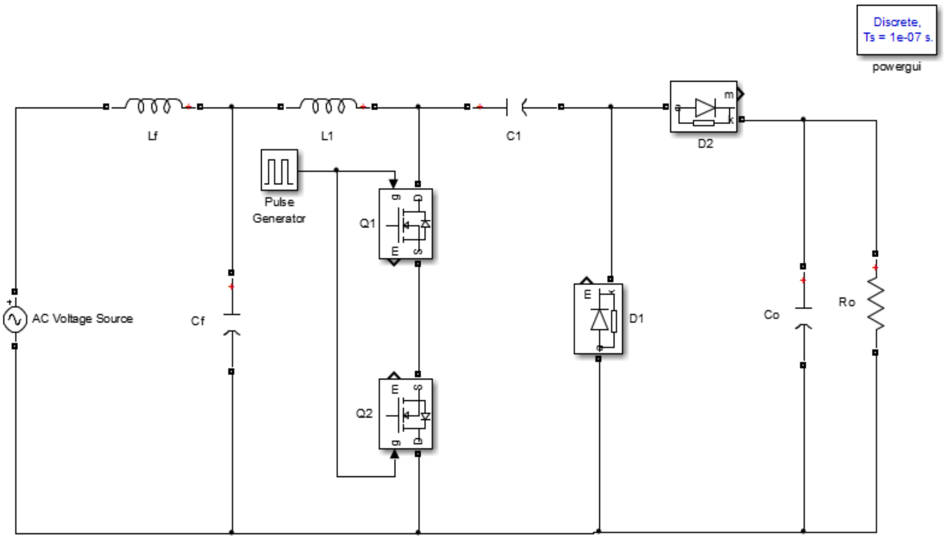

Fig. 6 Simulation diagram for open loop control

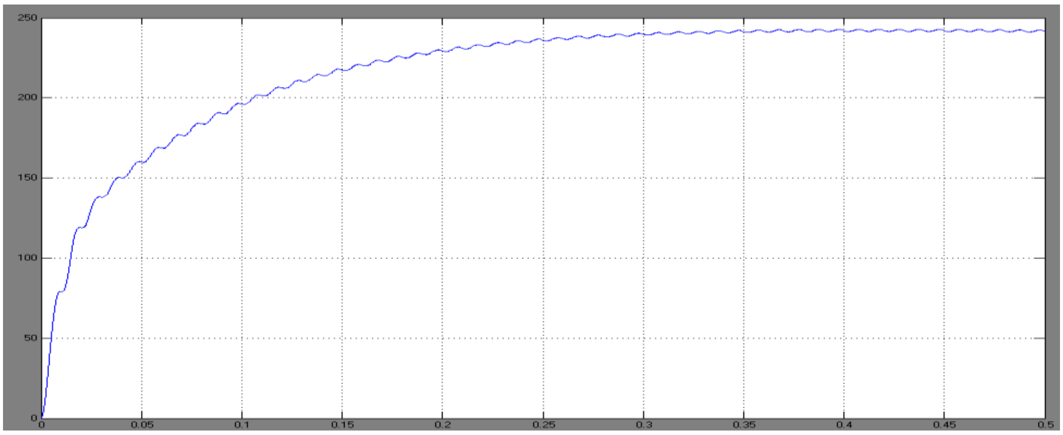

Fig. 7 Output waveform

Fig.7 shows the output voltage waveform. For an open loop system output voltage is at 240V across the load for 85Vrms input.

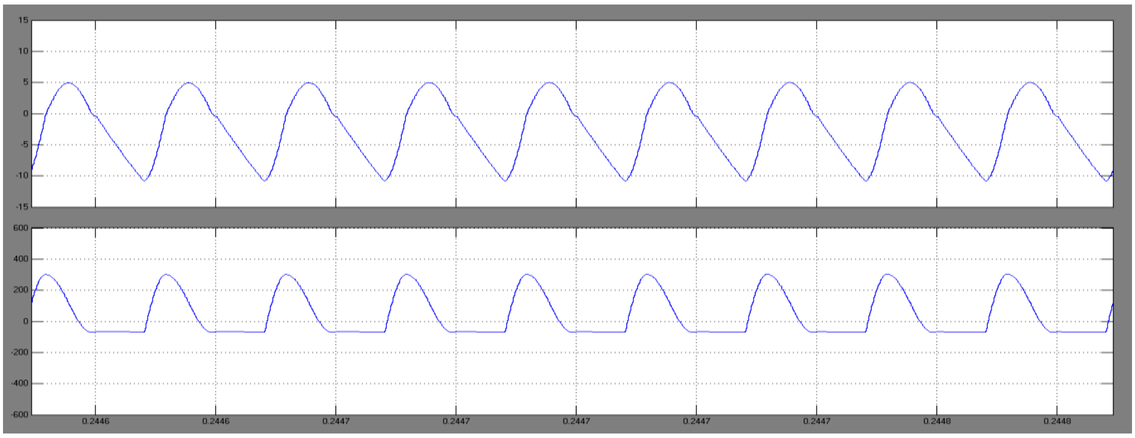

Fig. 8 the resonant inductor current i_{L1} and resonant capacitor voltage V_{c1}

Fig.8 shows the resonant inductor current i_{L1} and resonant capacitor voltage V_{c1} . During switch on time (Q_1) the inductor current through L_1 increases linearly with the input voltage, while the voltage across the capacitor C_1 remains constant.

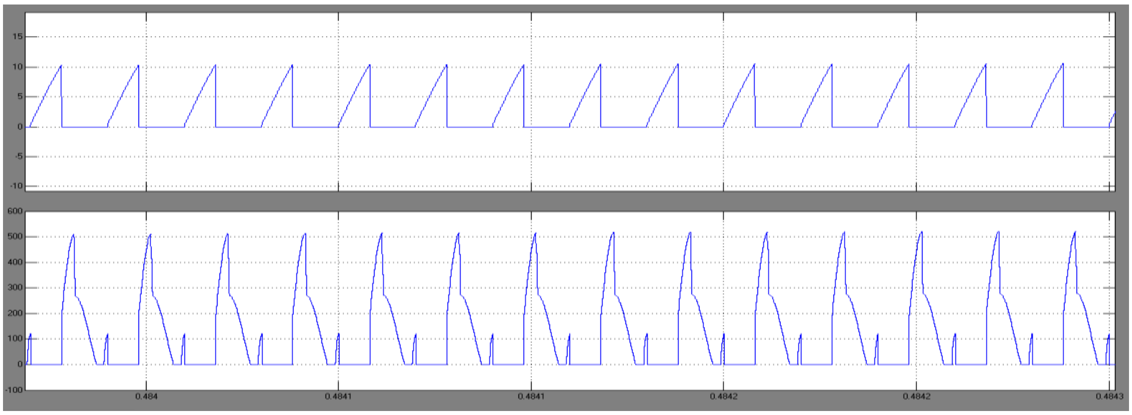

Fig. 9 current and voltage waveform of switch Q_1

Fig.9 shows the current and voltage waveform of switch Q_1 .From Fig.9, we can see that zero voltage is attained at the turn-on and turn-off of the switching devices by using this resonant circuit without using more resonating elements.

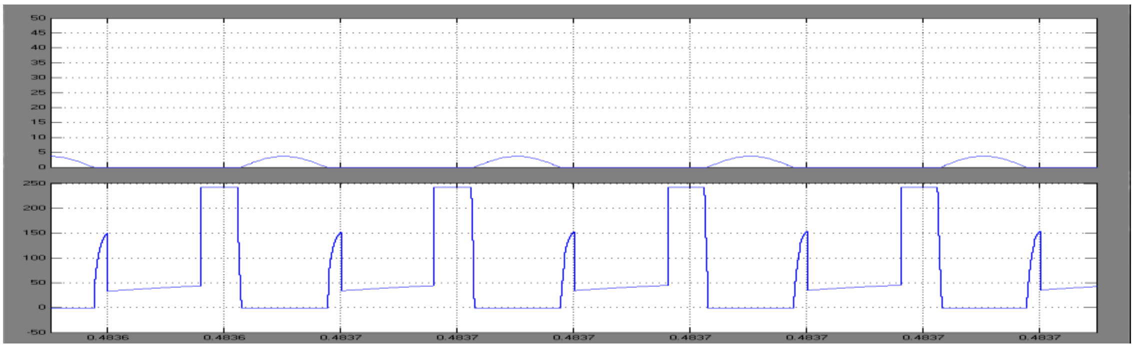

Fig. 10 current and voltage waveforms of Diode D_1

Fig.10 shows the current and voltage waveforms of diode D_1. It is evident from the figure that diode D_1 is turned off under zero current conditions.

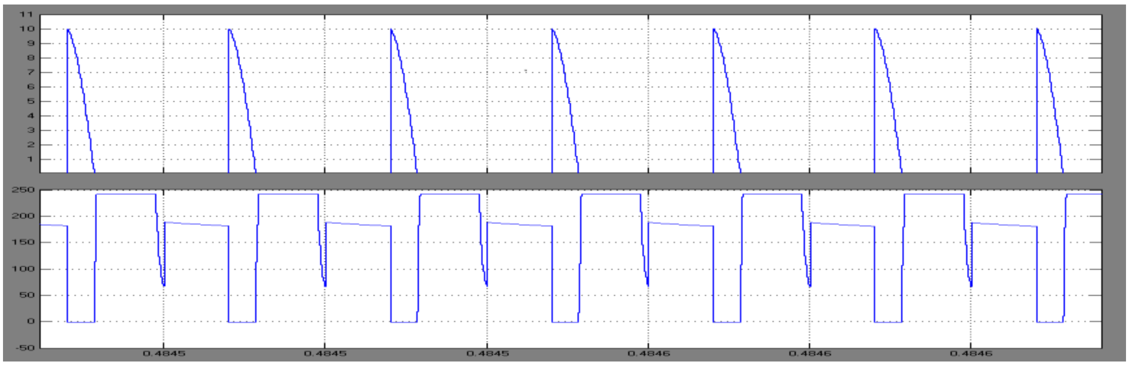

Fig. 11 current voltage waveforms of Diode D_2

Fig.11 shows the current and voltage waveforms of diode D_2. It is evident from the figure that diode D_2 is turned off under zero current conditions.

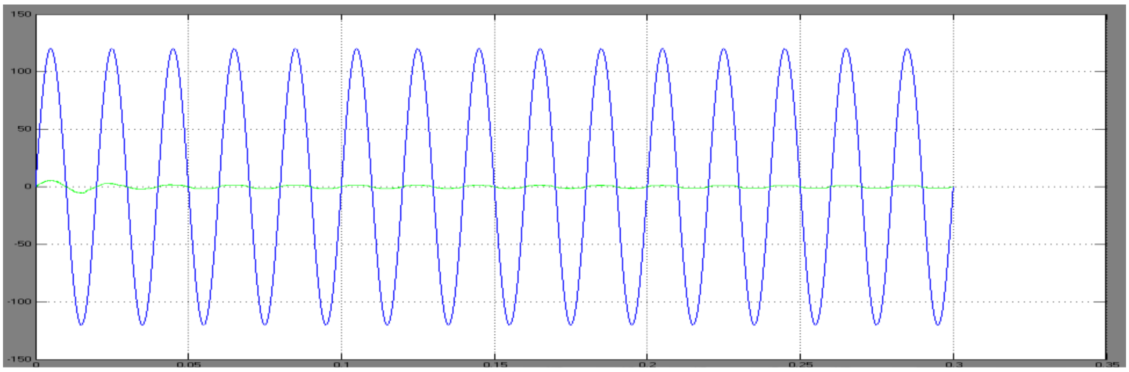

Fig.12 source voltage and current waveforms

Fig.12 shows the source voltage and current waveforms. It is clear from the figure that,input voltage and current are in phase. So that power factor is close to unity. From this simulation, obtained a PF value = 0.996 and THD= 0.18

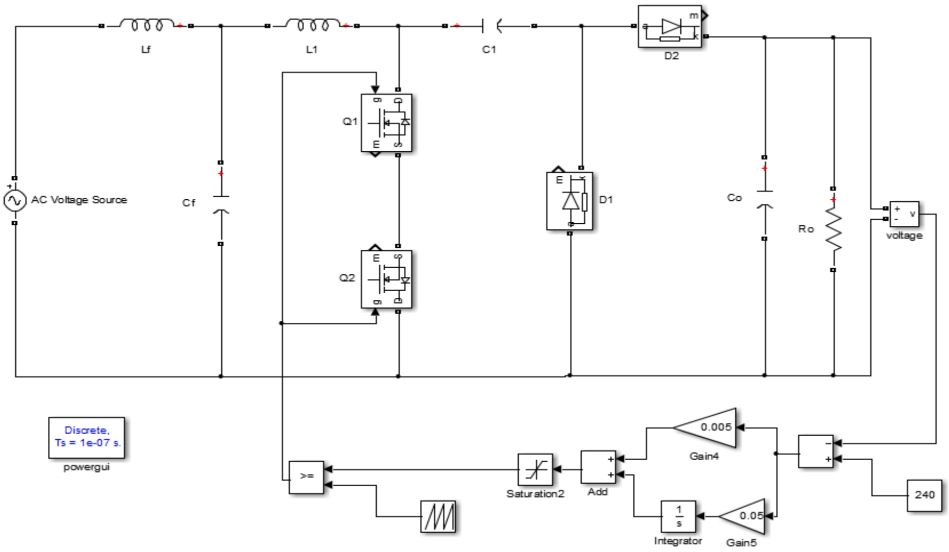

Fig. 13 Simulation diagram for closed loop control

DOI: 10.15662/ijareeie.2015.0408027

Closed loop simulation diagram of the proposed converter is shown in Fig.13. Here PI controller is used . In this closed loop simulation the output voltage control is used, so we need the output voltage feedback from the main circuit and this voltage is now compared with reference voltage .The error produced which is dependent on the output voltage is now sent to a PI controller. Kp value entered is 0.001,where as K_i value is taken as 1.It controls the error signal and is sent to a saturation block. This block keeps the error signal within the limits 0 to 1.

VI.CONCLUSION

Open loop and closed loop of a bridgeless pseudo boost PFC rectifier is analysed in this paper. Analysis is done based on the simulation results obtained from MATLABSIMULINK. In this converter obtaining power factor with less number of component count, it reduces conduction losses . This circuit is designed to operate in resonant mode to achieve an automatic PFC close to unity in a simple manner. The resonant mode operation gives additional advantages such as zero-current turn-on in the active power switches, zero-current turn-off in the output diode and reduces the complexity of the control circuitry. And closed loop simulation can be used to get a constant output voltage.

REFERENCES

[1] Abbas A. Fardoun, Mustafa A. Al-Saffar, Esam H. Ismail, Ahmad J. Sabzali, “A Bridgeless Resonant Pseudoboost PFC Rectifier,” IEEE Trans. power electronics, vol. 29, no. 11, november 2014

[2] L. Huber, Y. Jang, and M. Jovanovic’, “Performance evaluation of bridgeless PFC boost rectifiers,” IEEE Trans. Power Electron., vol. 23, no.3,pp. 1381–1390, May 2008.

[3] A. A. Fardoun, E. H. Ismail, A. J. Sabzali, and M. A. Al-Saffar, “A comparison between three proposed bridgeless cuk topologies and conventional topologies for power factor correction,” IEEE Trans. Power Electron.,vol. 27, no. 7, pp. 3292–3301, Jul. 2012.

[4] H. Wang, Y. Tang, and A. Khaligh, “A bridgeless boost rectifier for low voltage energy harvesting applications,” IEEE Trans. Power Electron., vol. 28, no. 11, pp. 5206–5214, Nov. 2013.

[5] M. Mahdavi and H. Farzanehfard, “Bridgeless SEPIC PFC rectifier with reduced components and conduction losses,” IEEE Trans. Ind. Electron.,vol.58,no.9,pp.4153–4160,Sep.2011.