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Simulation Of Bridgeless Resonant Pseudo boost PFC Rectifier

[1]Rajesh AV [2] Kannan suresh, [3]Renjith G [4]Amina E, [5]Arya MG [6]Arya MK [7]Veena M
[1] [2] [3] Assistant Professors, [4] [5] [6] [7],B.Tech scholors,
Department of EEE, College of Engineering , Perumon.
rajeshraj28@gmail.com
aminaillias2012@gmail.com

Abstract- **Proposed Pseudoboost rectifier is used for natural power factor correction due to their advantages of less componen4t count, high power density,less conduction loss and high efficiency. Power supplies with active power factor correction (PFC) techniques are becoming necessary for many types of electronic equipment to meet harmonic regulation and standards.This paper compared with conventional topology because of absence of input diode bridge and the presence of only one diode in the current path, thus improved the thermal management.To achieve an automatic power factor correction close to unity the topology work in resonant mode , which have the additional advantages such as zero- current turn- on in active switches and Zero- current turn-off in the output diodes which reduce complexity of the circuit. MATLAB/SIMULINK is used to obtain the simulation.**

Keywords: **Power factor correction (PFC), Bridgeless rectifier, Total harmonic distortion(THD)**

I. INTRODUCTION

Active power factor correction techniques are necessary adopted in telecommunication and computer industries to meet harmonic regulation and standards. Modern electronic equipment does not represent a completely passive load to the AC mains or power line. Most electronic systems now use one or more switch mode power converters that will tend to draw current from the power line in a non sinusoidal fashion. This input current characteristic results in current and possibly voltage distortions that can create problems with other equipment connected to the power line and degrade the capability of the mains. These problems have led to the creation of design standards for the purpose of limiting the allowable harmonic distortion on the power line. Fortunately, solutions are available for meeting these standards. These solutions are referred to as Power Factor Correction (PFC) techniques. Conventional PFC scheme has lower efficiency due to significant losses in the diode bridge.Most of the PFC rectifiers utilize a boost converter at their front end. However, a conventional PFC scheme has lower efficiency due to significant losses in the diode bridge. Which leads a significant conduction loss, caused by the forward voltage drop across the bridge diode, would degrade the converters efficiency, especially at a low line input voltage.

Bridgeless PFC circuit allows the current to flow through the minimum number of switching devices. Previous PFC converters have drawbacks such as high component count, components are not fully utilized over whole ac line cycle, complex controlled output voltage is always higher than peak input voltage, lack of galvanic isolation and due to floating ground, some topologies require additional diodes and/or capacitors to minimize EMI. Inorder to overcome these problems proposed topology with two semiconductors in current conduction path during each switching cycle is presented. The proposed topology has low component count, single control signal and non floating output.

Proposed topology operates in discontinuous conduction mode for low power application. It has one less component than Totem-pole bridgeless PFC boost rectifier. The proposed topology not be consider as an “ideal” automatic current shaper, since the input current
is not directly propotional to input voltage for a constant duty cycle.

II. REVIEW OF PRESENT POWER FACTOR CORRECTION STAGE

For Active power factor correction, the standard rectifier employing a diode bridge followed by a filter capacitor gives unacceptable performances. Thus, many efforts are being done to develop interface systems which improve the power factor of standard electronic loads. Among three basic power converter topologies (boost, buck and buck-boost), the boost converter is the one most suitable for power factor correction applications. This is because the

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inductor is in series with the line input terminal through the diode rectifier, which gives lower line current ripple and continuous input current can be obtained with an average current mode. As a result, a small line input filter can be used. The buck-boost and yback converters are able to control the average line input current. However, the power handling capability is smaller because of its higher voltage and current stresses. Therefore, the boost converter is currently the most popular PFC topology.

A conventional PFC Boost rectifier consists of AC input voltage source, bridge rectifier with diodes input inductor, controllable switch, diode, filter capacitor, and load resistance. An important advantage of this topology is that continuous current is present at both the input and the output of the converter. Disadvantages of the conventional Boost converter are a high number of reactive components and high current stresses on the switch, and the diode. During each switching cycle, the current flows through three semiconductor devices. As a result, a significant conduction loss, caused by the forward voltage drop across the bridge diode.

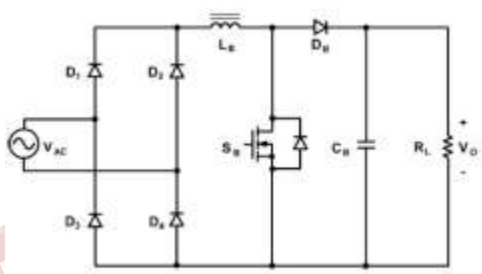

Fig1 Conventional Boost PFC converter

A bridgeless PFC rectifier allows the current to flow through a minimum number of switching devices compared to the conventional Boost rectifier. It also reduces the converter conduction losses and which improves the efficiency and reducing the cost.

III. PRINCIPLE OF OPERATION

The bridgeless pseudoboost rectifier designed to operate in discontinuous-conduction mode (DCM) during the switch turn-on interval and in resonant mode during the switch turn off intervals. Moreover, the two power switches Q1 and Q2 can be driven by the same control signal, which signifiicantly simplifies the control circuitry. However, an isolated gate drive is required for the power switch Q1 .

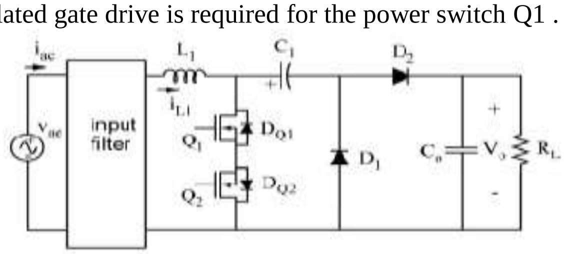

Fig 2 Proposed pseudo boost converter

There are four modes of operation in DCM. The first stage(t_0-t_1) starts when the switch Q1 is turned-on. The body Diode of Q2 is forward biased by the inductor current i_{L1} Diode D1 is reverse biased by the voltage across C1 , while D2 is reverse biased by the voltages Vc1 + Vo . In this stage, the current through inductor L1 increases linearly with the input voltage, while the voltage across capacitor C1 remains constant at voltage vx.

During the second stage [t1, t2] when switch Q1 is turned OFF and diode D2 is turned ON simultaneously providing a path for the inductor currentsiL1. As a result, diode D1 remains reverse biased during this interval. The series tank consisting of L1 and C1 are excited by the input voltage Vac through diode D_2. The stage ends when the resonant current iL1 reaches zero and diode D2 turns OFF with zero current. During this stage, capacitor C1 is charged until it reaches a peak value.

During the third stage [t2,t3] During this stage diode D1 is forward biased to provide a path during the negative cycle of the resonating inductor current iL1. This stage ends when the inductor current reaches zero. Thus, during this stage diode D1 is switched ON and OFF under zero current conditions. Assuming the constant input voltage over a switching period, the capacitor is discharged until it reaches a voltage Vx.

During the fourth stage [t3,t4] switches are in their off state. The inductor current is zero, while the capacitor voltage remains constant.

The resonant mode achieves an automatic PFC close to unity in a simple and effective 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.

IV. DESIGN PROCEDURE

In pseudoboost rectifier V_{ac}=13V, V_0=24V,
P_{out}=115W and f_s=50kHz.
The equations are derived from the base quantities such as
Base voltage=Output voltage,V_o (1)

$$\text{Base impedence}=Z_0=\sqrt{\frac{L_1}{C_1}} \quad (2)$$

$$\text{Base current}=\frac{V_0}{Z_0} \quad (3)$$

Base frequency,

$$Fr=\frac{\omega_r}{2\pi}=\frac{1}{2\pi\sqrt{L_1C_1}} \quad (4)$$

The circuit components are designed by assuming the efficiency as 100%.
1.The voltage conversion ratio,

$$M=\frac{Vo}{V_m}=\frac{d_1}{\sqrt{2K}}=\sqrt{\frac{RL}{2R_e}} \quad (5)$$

Since, $R_e=\frac{2L_1}{d_1^2 T_s}$ (6)

The value of M is obtained by

$$M=\frac{Vo}{V_m}=\frac{24}{\sqrt{2}*13}=1.305 \quad (7)$$

2. For ensuring the DCM operation,the normalised switching frequency must be less than one.So for that F is chosen as 0.8

3. *The diamensionless conduction parameter ,*

$$K=\frac{2L_1}{R_L T_s} \quad (8)$$

$$K<\frac{1}{2}\times\left(\frac{f}{\pi}\right)^2=K_{cr} \quad (9)$$

From these the value of critical inductance required to maintain DCM operation is

$$L_1\leq\frac{R_L T_s}{4}\times\left(\frac{f}{\pi}\right)^2 \quad (10)$$

4. The value of resonant capacitance can be calculated from (4)

$$C_1=\frac{1}{L_1(2\pi fr)^2}=65nF \quad (11)$$

The switch duty cycle,

d_1=M sqrt(2K)=0.4 (12)

5. Input power factor

$$PF=\frac{(P_{in(t)})_{TL}}{V_{ac,\,rms} I_{ac,\,RMS}}. \quad (13)$$

6. The line current distortion is represented by the factor total harmonic distortion (THD).THD is the ratio of harmonic contents to the fundamental contents. It can be calculated by using the relation

$$THD=\frac{\sqrt{\sum_{n=2}^{\infty} I^\wedge 2_{ac,\,rms(n)}}}{I_{ac,\,rms(1)}} \quad (14)$$

The total harmonic distortion and power factor can be related as

$$THD=\sqrt{\left(\frac{\cos(\theta_1)}{PF}\right)^2-1} \quad (15)$$

TABLE 1: PARAMETERS

Parameters	Values
Tank Inductor,L_1	100uH
Tank Capacitor,C_1	65nF
Filter Inductor,L_F	1mH
Filter capacitor,C_F	1uF
Output Filter,C_0	470uF

V. SIMULATION RESULT AND TOPOLOGY COMPARISON

The pseudo boost converter has been simulated using MATLAB.The input and output specifications are,V_{ac} = 13V, V_o = 24V, and f_s =50KHz.The duty cycle is selected as 40%. MATLAB simulation is used for the analysis of the circuit.The current in the inductor L_1 consist of ripple. In order to filtering the ripple current a small high frequency input filter is introduced in the circuit..From the simulation result it can be observed that the switch Q1 turns on under zero current condition.

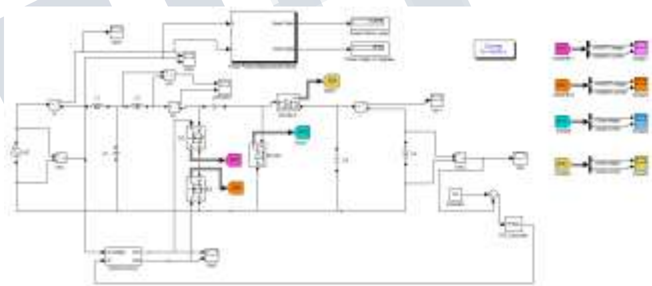

Fig 3: Simulation of proposed pseudoboost converter

Fig shows the input current of a conventional boost

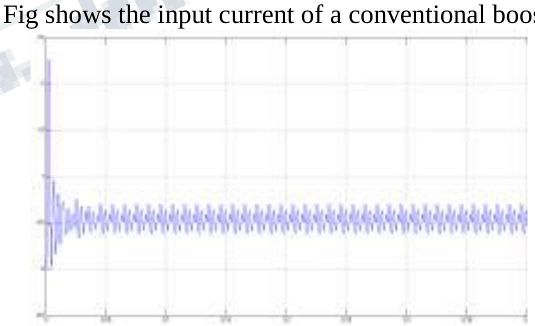

Fig3(a) : input current of the boost rectifier

Fig shows the output current and voltage wave form of conventional boost

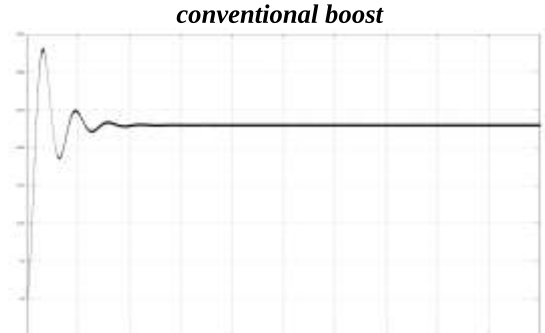

Fig3(b) : output waveform of Boost converter

Compared to conventional boost PFC converters the proposed pseudo boost converters suffer from high voltage stress on the MOSFET switches and the capacitor at high lines. The high switching stress result in high switching losses. Thus the current reduces and conduction loss decreases.

Fig shows input current and voltage o psudoboost rectifier

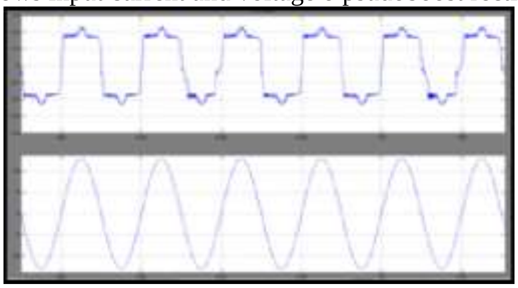

Fig3(c):input current &voltage of pseudoboost

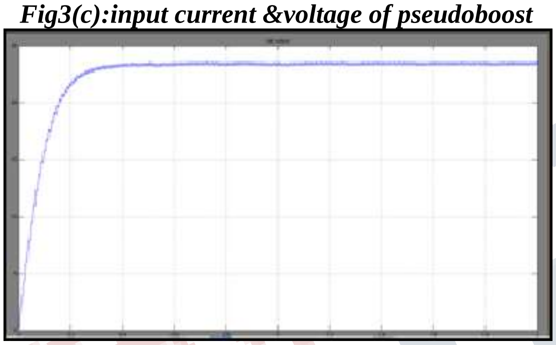

Fig 3 (d) Output Wave form of pseudo boost

But for low line,the current drawn from the main is very high. As a result coduction loss increases but the voltage stress across the capacitor and switches reduces.Thus for the circuit the overall component losses that is switching and conducting losses balance out at high and low line voltages

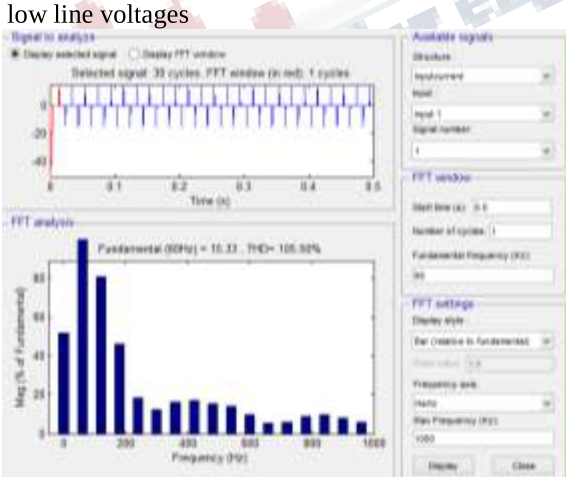

Fig3(e) : THD of Boost rectifier

THD of conventional boost converter is 105.5%of fundamental.Thus power factor of the boost converter is reduced.

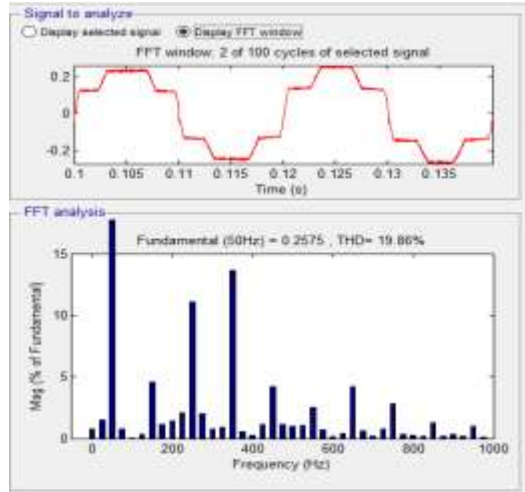

Fig3(f) : THD of pseudoboost rectifier

In proposed pseudoboost topology in closed loop configuration will gives a THD of 19.86% of fundamental. Thus power factor improved than conventional

In order to filtering the ripple current a small high frequency input filter is introduced in the circuit. Select the filter inductance as L_f=1 mH and filter capacitance as C_f=1uF. The simulated voltage and current waveform of the proposed converter under full load condition in given in the fig:.3.From fig3 it is clear that the input voltage and input line current. The voltage and current wave form of the MOSFET switch Q1 is given in the fig3(h).From the simulation result it can be observed that the switch Q1 turns on under zero current condition.The fig3(g) represents the voltage and current waveform across the diode D1 and that of D2 .From fig it is clear that both the diodes will turn off under zero current condition.

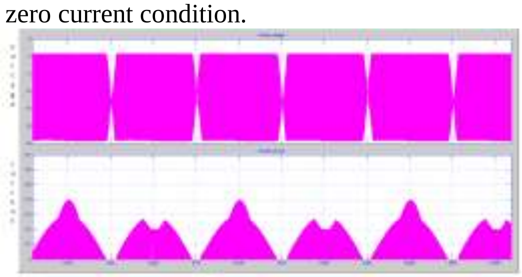

Fig 3(g): input voltage and current waveform of diode

The voltage and current waveform across MOSFET Q1of pseudoboost rectifier is shown below.

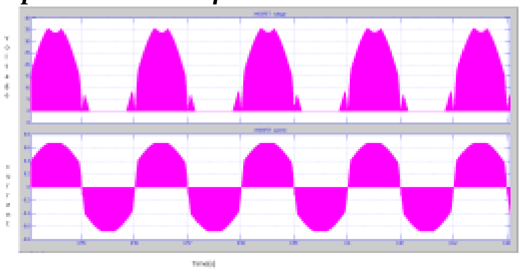

Fig 3(h): Voltage &Current waveform of Q1

VI. CONCLUSION

The design procedure of the bridgeless resonant pseudoboost converter is analysed. From the MATLAB simulink model and the simulation waveforms obtained are presented. From the simulation results we can see the power factor of 0.9808 is obtained that is almost close to unity. The converter topology were simulated and tested using MATLAB Simulink environment.

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