Simulation Of Bridgeless Buck PFC Converter

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Abstract

Conventional buck power factor correction rectifiers have high conduction losses and switching losses due to the presence of input rectifier bridges. The bridgeless buck converter improves the efficiency by reducing the conduction losses by using lesser number of semiconductor devices. This circuit also works as a voltage doubler circuit. Although the output voltage is doubled the switching losses of the devices connected at the dc/dc output stage is lower than the boost power factor correction rectifier. This paper presents simulation of bridgeless PFC buck converter in MATLAB software.

Keywords - Power factor correction (PFC), Bridgeless rectification, buck converter, conduction loss, switching loss

1.Introduction

Presently, maintaining high efficiency along the entire line range (90-264V) becomes a challenge for the ac-dc converters that are used for power factor correction. There is also requirement of high power factor and low total harmonic distortion in the current drawn from the utility. Various topologies have been introduced in this respect for attaining high power factor and low harmonic distortion.

The boost topology was the widely used topology at the earlier stage.Conventional boost bridge PFC rectifier comprises of full bridge rectifier followed by a boost converter. This bridge arrangement has high conduction losses due to the number of semiconductor devices and hence the efficiency is less. To reduce this loss a bridgeless boost topology[3] was introduced which eliminates the use of bridge rectifier.

Even though boost PFC is efficient, the output voltage of boost converter is greater than the input which facilitates the use of higher rating semiconductor devices at the downstream. The drawback of universal line boost PFC front end can be overcome by implementing buck PFC topology[2]. This paper analyses the bridgeless buck converter which further improves the efficiency of the buck converter[1] by minimizing the number of simultaneously conducting devices. This converter also works as a voltage doubler circuit whose output voltage is twice the input voltage.Eventhough the output voltage is doubled the switching losses at the downstream is lower than the boost frontend.

The bridgeless PFC buck topology improves efficiency at low line of the universal line range than the bridgeless boost PFC rectifier.

2.Bridgeless PFC circuit

The circuit of a bridgeless buck converter is shown in fig 1. Here two buck converters are connected in back to back. During positive half cycle buck converter consisting of switch S1,diode D1,freewheeling diode D3,Inductor L1,Capacitor C1 operates. The voltage across C1 is regulated by pulse width modulation of the switch S1.During negative half cycle switch S2,freewheeling diode D4,diode D3,Inductor L2 and capacitor C2 operates. Here the output voltage across C2 is regulated by pulse width modulation of switch S2.The voltage available at the output resistor is the sum of the voltages across capacitors C1&C2.

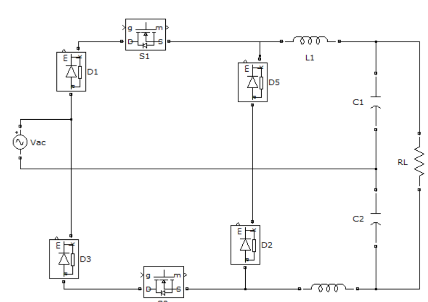

Fig.1.Bridgeless PFC converter

Since the output voltage of the bridgeless buck converter is the sum of voltage across two capacitors
Vo=2DVin

2.1.Positive half cycle:

During positive half cycle the buck converter comprising of diode D1,switch S1,inductor L1,capacitor C1 and freewheeling diode D3 is operating. When switch S1 is on, the inductor L1 stores energy and the current path is through diode D1,switch,inductor L1,capacitor C1.When the switch is off the current freewheels through the diode D3.The voltage across the capacitor is regulated by the pulse width modulation of switch S1.The buck converter which is operating during positive half cycle is shown in bold lines.

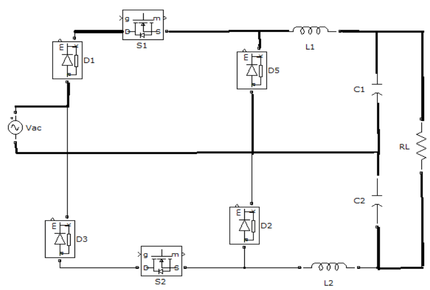

Fig.2.Operation during positive half cycle

2. Negative half cycle:

During the negative half cycle the buck converter consisting of switch S2,diode D2,inductor L2,capacitor C2 and the freewheeling diode D3 operates. When the switch is on the inductor L2 stores energy and when the switch is off, the energy is discharged through the freewheeling diode D4.The output voltage of each buck converter is available across the capacitors. Since the direction of current is in the same direction in both the capacitors, the output voltage obtained across the load resistor is twice the voltage obtained at any of the buck converter. The buck converter operating during the negative half of the line voltage is shown in bold lines in the figure given below

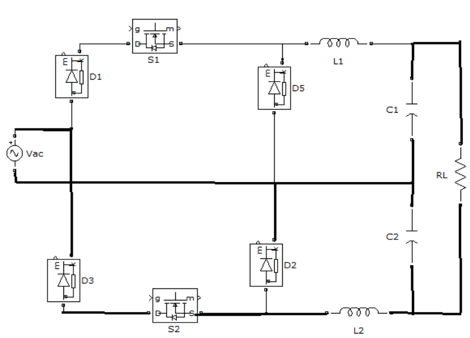

Fig.3.Operation during negative half cycle

3. Modified bridgeless buck converter

A modified bridgeless buck converter is shown in the figure below. Here the two inductors of the individual buck converter has been replaced by a single inductor which is connected at the midpoint of the two capacitors. The magnetic component utilization is better in this circuit. But the disadvantage is that it will introduce common mode noise.

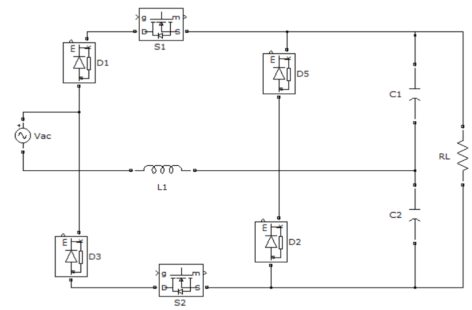

Fig.4.Bridgeless buck with single inductor

4. Simulation & Results

Simulation is done in MATLAB and the result obtained are shown. Simulation of the bridgeless buck converter with two inductors and with single inductor is performed. The PWM signal required for providing gate pulses to the switches of the buck converters are generated by comparing the ramp signal with the reference. The input current and voltage is shown in fig. 5.c .The input current waveform with two inductors and a single inductor is shown in figure 5.d&5.e respectively
Similarly, the Voltage across MOSFET 1 & 2 is shown in fig. 8d & 8e respectively. Further, the output dc voltage and current are shown in fig. 8f & 8g respectively.
The simulink model of the bridgeless buck converter is shown below.

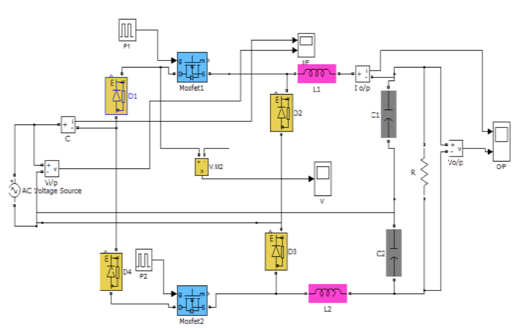

Fig.5.a.Bridgeless Buck converter with two inductor

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The simulink model of bridgeless buck converter with single inductor is as shown

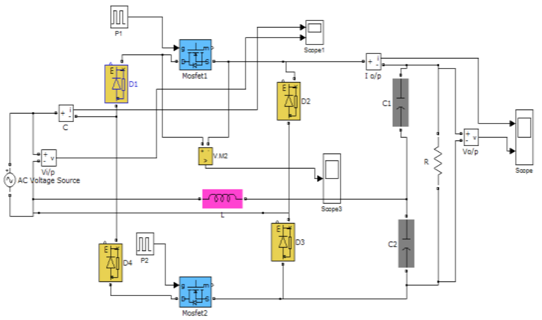

Fig.5.b.Bridgeless buck converter with single inductor

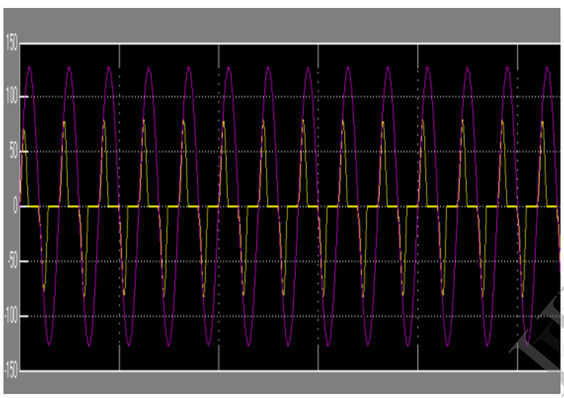

Fig.5.c.Input voltage and current waveform

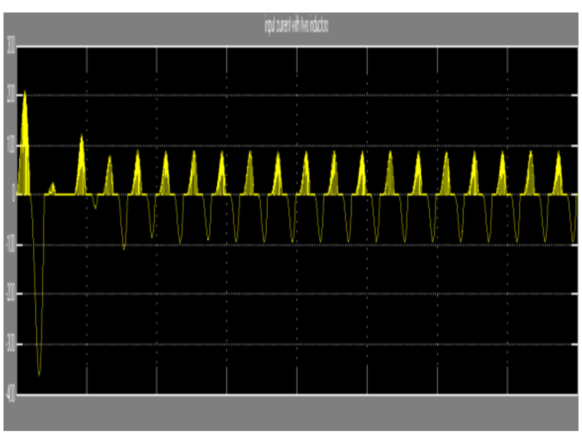

Fig.5.d.Input current waveform with two inductors

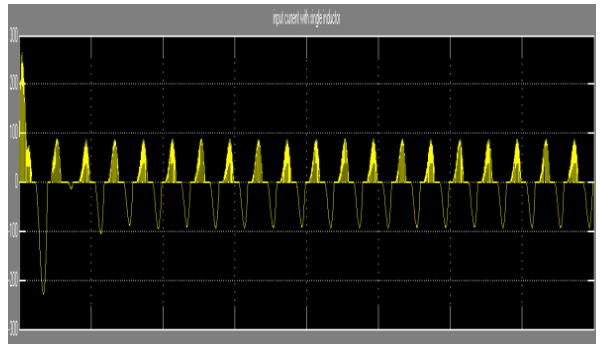

Fig.5.e.Input current waveform with single inductor

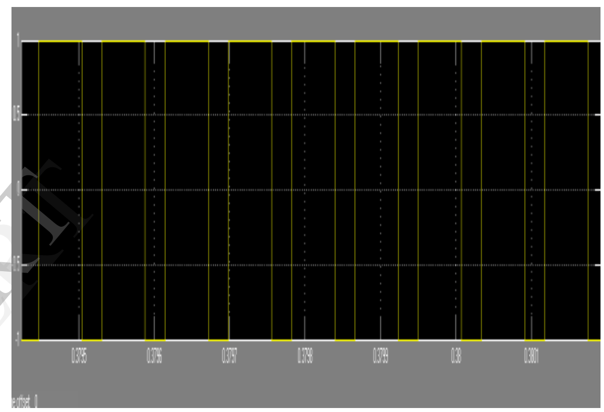

Fig.5.f.PWM across switches

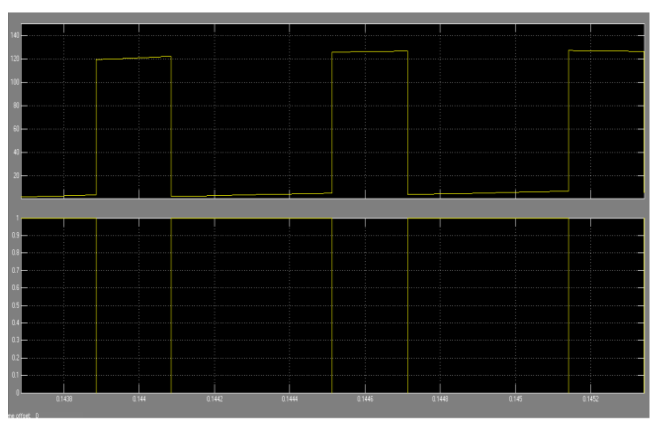

Fig.5.g.Voltage across switches S1&S2

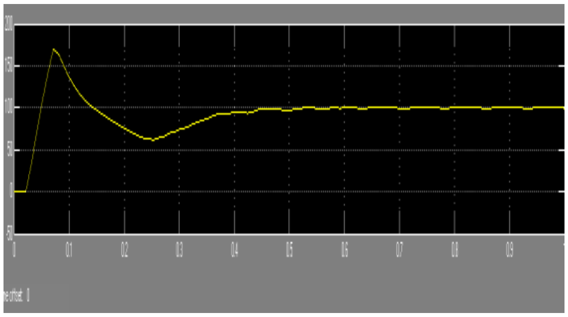

Fig.5.h.Output voltage waveform

5. Conclusion

In this paper a bridgeless buck PFC converter with two inductors and with single inductor has been analysed, modelled and simulated in matlab.This bridgeless PFC is having two buck converters connected back to back. since number of conducting devices are less as compared to the bridge circuit the conduction losses and switching losses are less. The input current and voltages are almost in phase which represents a high power factor. The single inductor topology is having higher common mode noise as compared to the two inductor topology even though the magnetic utilization is better.

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