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# Active Power Factor Correction Using Bridgeless Buck-Boost Converter

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**ABSTRACT:** The power factor of an AC electrical power system is defined as the ratio of the real power to the apparent power in the circuit. Real power is the capacity of the circuit to do useful work. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power, and so the power factor will be less than one always. A negative power factor occurs in special cases, when the device or the load generates power which then flows back towards the source which is normally considered the generator. In an electric power system, a load with a low power factor draws more current than a load with a high power factor system and many associated loss occurs. Linear loads with low power factor can be corrected with a passive network of capacitors or inductors and is preferred for high power applications also. Non-linear loads, such as rectifiers, distort the shape of the current drawn from the system. In such cases, active or passive power factor correction may be used to shape the distorted wave and raise the power factor. This paper mainly deals with the active power factor correction using high frequency switching converters.

**KEYWORDS:** Active power factor correction, power factor, bridge less converter, buck-boost converter.

## I. INTRODUCTION

In a purely resistive AC circuit, voltage and current waveforms are in phase, changing its polarity at the same instant of time in each cycle. A linear load change the phase between voltage and current, like Inductive loads such as transformers and motors or any type of wound coil consume reactive power with current waveform lagging the voltage. A non-linear load such as a rectifier or some kind of arc discharge device such as a fluorescent lamp, electric welding machine, or arc furnace change the shape of the current waveform from a sine wave to some other form. because current in these systems is interrupted by a switching action. The current contains frequency components that are multiples of the power system frequency. Hence non-linear loads create harmonic currents in addition to the original (fundamental frequency) AC current.

So in linear circuits having only sinusoidal currents and voltages of one frequency, the power factor arises only from the difference in phase between the current and voltage. This power factor can be called as "displacement power factor". Now take case of SMPS which is a nonlinear load, which uses a large electrolytic capacitor at the output side of the single phase rectifier, to reduce the output voltage ripple. In this case the rectifier diodes conduct only when the line voltage is higher than the capacitor voltage. As a result the power supply draws an input current which is pulsating in nature. This distorted line current has a low power factor. Power factor due to this distortion of line current can be called as "distortion power factor".

## II. DEFINITION OF POWER FACTOR AND THD

Power factor is a very important parameter in power system, because it gives a measure of how effective the real power is utilized in the system. It also represents a measure of distortion of the line voltage and the line current waves and phase shift between them. In Fig. 1, we define the input power factor (PF) at terminal a-a' as the ratio of the average power to the apparent power measured at terminals a-a' as described in below equation

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent power}} \quad \text{Eqn (1)}$$

where, the apparent power is defined as the product of rms values of  $v_s(t)$  and  $i_s(t)$ . In a linear system, as load draws purely sinusoidal current and voltage, the PF is only determined by the phase difference between  $v_s(t)$  and  $i_s(t)$ . Then above equation becomes

$$pf = \frac{I_{s,rms} V_{s,rms} \cos \theta}{I_{s,rms} V_{s,rms}} = \cos \theta \quad \text{Eqn (2)}$$

where,  $I_{s,rms}$  and  $V_{s,rms}$  are rms values of line current and line voltage, and  $\theta$  is the phase shift between line current and line voltage. Hence, in linear systems, the PF is simply equal to the cosine of the angle between the current and voltage. However, non-linear system, the phase-angle representation alone is not valid. Fig 1 shows that the non-linear load draws typical distorted line current from the line. So in that case the power factor can be represented as in Eqn(3) as below

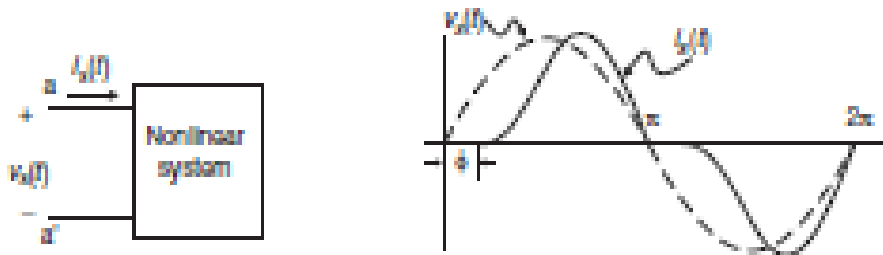


Fig 1 Non-linear system

$$Pf = \frac{\sum_{\alpha=1}^n I_{s,n,rms} V_{s,n,rms} \cos \theta_n}{I_{s,rms} V_{s,rms}} \quad \text{Eqn (3)}$$

where,  $V_{s,n,rms}$  and  $I_{s,n,rms}$  are the rms values of the nth harmonic voltage and current, respectively, and  $\theta_n$  is the phase shift between the nth harmonic voltage and current. Since the distortion is only limited to current, the above equation becomes

$$pf = \frac{I_{s1,rms} \cos \theta_1}{I_{s,rms}} = k_{dist} \times k_{disp} \quad \text{Eqn (4)}$$

where,

$\theta_1$ : the phase angle between the voltage  $v_s(t)$  and the fundamental component of  $i_s(t)$

$k_{dist} = I_{s1,rms} / I_{s,rms}$  : distortion powerfactor;

$k_{disp} = \cos \theta_1$ : displacement powerfactor.

Another important parameter that measures the percentage of distortion is known as the current total harmonic distortion (THDi) which is defined as follows:

$$THDi = \sqrt{\frac{\sum_{n=2}^{\infty} I_{s,n,rms}^2}{I_{s1,rms}^2}} = \sqrt{\left(\frac{1}{k_{dist}^2} - 1\right)} \quad \text{Eqn (5)}$$

### III. ACTIVE BUCK BOOST CORRECTOR

In this paper we concentrate on the active power factor correction method by using high-frequency switching techniques to shape the input current waveform.

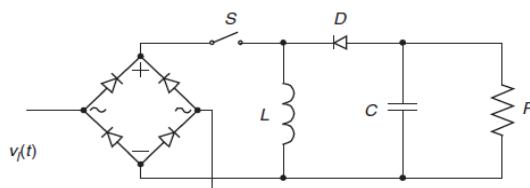


Fig 2. Buck-Boost corrector

Figure shows the proposed BL buck–boost. The buck–boost corrector has some advantages of the buck corrector and the boost corrector. Like a buck converter, it can provide circuit protections and step-down output voltage, and like a front end boost converter its input current waveform and output voltage can be tightly controlled. However, the buck–boost corrector has the following disadvantages:

- (a) The input current is discontinued by the power switch, as a result high differential mode EMI;
- (b) The current stress is high on the power switch ;
- (c) The power switch needs a floating drive;
- (d) The polarity of output voltage is reversed.

#### IV. BRIDGELESS BUCK BOOST CORRECTOR

The need for higher efficiency from the PFC stage has led to think of possible lower loss alternatives. One section that has a major contribution to the losses is the input bridge rectifier. In a full bridge rectifier the input current must flow through two diodes before entering to the power factor correction stage. So by eliminating full bridge the front end consists of two switching cells ,each consisting of a power MOSFET and diode as shown in below figure.

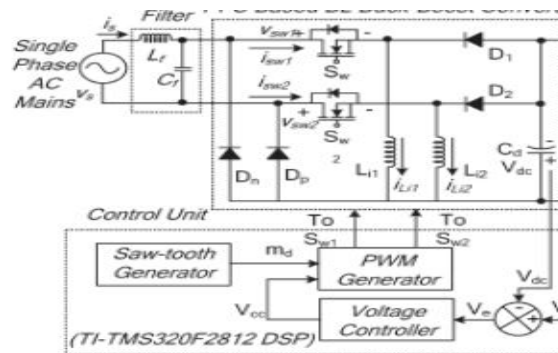


Fig 3. Bridge less Buck-Boost converter

The choice of mode of operation of a PFC converter is an important issue because it directly affects the cost and rating of the components used in the PFC converter. The continuous conduction mode (CCM) and discontinuous conduction mode (DCM) are the two modes of operation in which a PFC converter is designed to operate. The CCM requires complex controlling , which is not cost effective but DCM requires comparatively less control arrangement like a single voltage sensor for dc link voltage control, and inherent PFC is achieved at the ac mains, hence DCM is preferred for low-power applications and this paper discusses operation of bridgeless buck-boost PFC converter in DCM mode.

#### V. WORKING

Working of the circuit during positive half cycle and negative half cycle of supply voltage . During the positive half cycle of the supply voltage is discussed separately. During positive cycle, switch Sw1, inductor Li1, and diodes D1 and Dp are operated to transfer energy to dc link capacitor Cd.

##### Operation during negative half cycles of supply voltage

**Mode I:** In this mode, switch Sw1 is on to charge the inductor Li1; hence, an inductor current iLi1 increases in this mode. Diode Dp completes the circuit of input side , whereas the dc link capacitor Cd is discharged to the load.

**Mode II:** In this mode of operation, switch Sw1 is turned off, and the stored energy in inductor Li1 is transferred to dc link capacitor Cd till the inductor is completely discharged. The current in inductor Li1 reduces and reaches zero.

**Mode III:** In this mode, inductor Li1 enters discontinuous conduction, i.e., no energy is left in the inductor; hence, current iLi1 becomes zero for the rest of the switching period. none of the switch or diode is conducting in this mode, and dc link capacitor Cd supplies energy to the load; hence, voltage Vdc across dc link capacitor Cd starts decreasing. The operation is repeated when switch Sw1 is turned on again after a complete switching cycle.

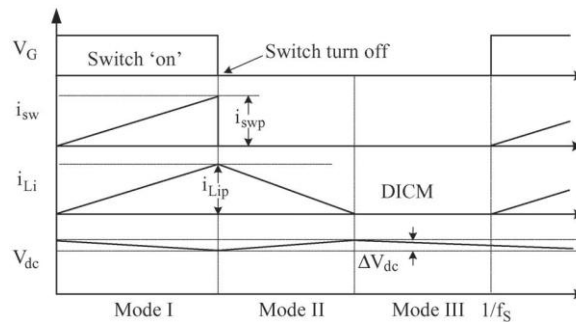


Fig 4. Waveforms during complete switching cycle

### Operation during negative half cycles of supply voltage

Operation during negative half cycles of the supply voltage, switch Sw2, inductor Li2, and diodes D2 and Dn conduct .

**Mode 1:** The switch Sw2 is conducting and as result of this the inductor charges and the inductor current  $i_{Li2}$  increases. The diode Dn completes the circuit. The previously stored charge in DC link capacitor will be transferred to the load .

**Mode 2:** During this mode of operation, the switch Sw2 turns off and the energy stored in inductor will be transferred to the DC link capacitor and the current  $i_{L2}$  will be decreased..

**Mode 3:** In this mode none of the switch and the diode are conducting. The inductor enters into the discontinuous mode since the inductor current become zero. The energy stored in the DC link capacitor Cd will be transferred to the load. The Switch Sw2 conducts again after the complete switching cycle.

## VI. SIMULATION AND RESULTS

### A) Simulink model of the Bridgeless Buck-Boost converter

Simulation of proposed bridgeless buck- converter has been performed in MATLAB/Simulink .The converter has been designed to work in DCM mode

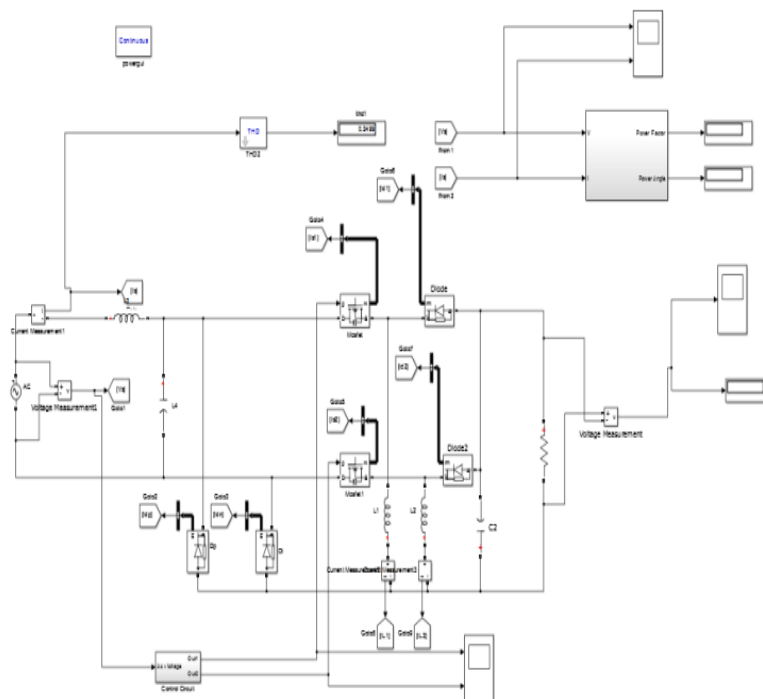


Fig 5. Simulink model of the Bridgeless Buck-Boost converter



B) Input voltage and current of Bridgeless Buck-Boost converter

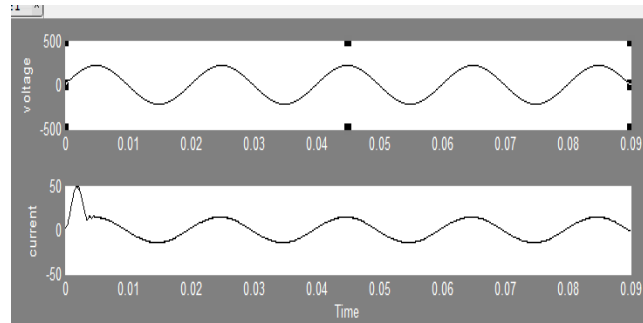


Fig 6. Input voltage and current of Bridgeless Buck-Boost converter

C) THD spectrum of input current

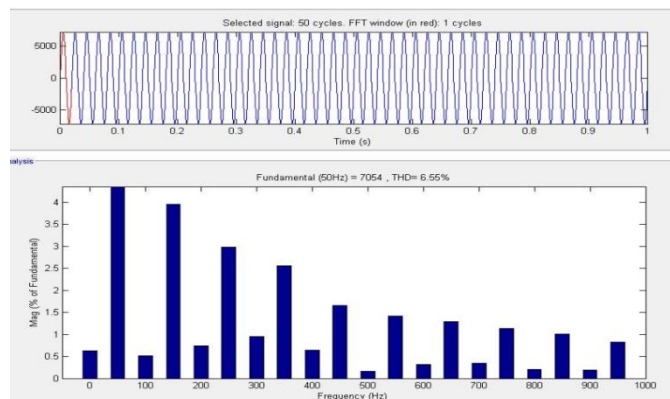


Fig 7. THD spectrum of input current

## VII. CONCLUSION

A PFC BL buck–boost converter has been proposed targeting low-power applications. The simulation of bridgeless dual buck boost converter operating in DICM, has been done. The front-end Bridgeless buck–boost converter has been operated in DCM for achieving an inherent power factor correction at ac mains.

With this proposed converter the power quality can be improved at the AC mains. The power factor can be improved up to 0.96 with this arrangement.

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