REDUCTION OF HARMONICS IN ELECTRONIC BALLAST USING BUCK BOOST CONVERTER

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ABSTRACT
This paper is based on the design and analysis of Total Harmonic Distortion (THD) and power factor for Compact Fluorescent Lamp. In the proposed electronic ballast Buck boost converter operates in the continuous conduction mode, which provides a constant DC voltage to drive the lamp. By choosing the switching frequency more than the resonant frequency, the zero voltage switching is achieved in resonant inverter. The design and simulation of the proposed topology using MATLAB-Simulink for the rms value of 220 V the total harmonic distortion is reduced by 15% and the power factor is improved to 0.98.

KEYWORDS — Buck Boost converter, THD, Power Factor.

INTRODUCTION
In earlier days the incandescent light is dominated in the lighting industry. But due to their low level of lumen capacity and efficiency the consumption level is reduced to improve that high power factor LED and CFL bulbs have been introduced. The LED has more advantages with long lifetime, robustness, and small size, but in cost it was economically high and also need more concentration on heat management. Due to overheating of LED bulbs there may be a possibility of device failure. To overcome these issues CFL proves itself to be superior to the LED bulb. Generally, all lamps required adequate voltage for ignition at the time of starting current limiting control which essentially creates a negative impedance characteristic. In CFL lamp, to reduce the negative impedance characteristics the ballast is used to provide the constant voltage for ignition. Magnetic ballast made up of magnetic core and is larger in size produces a core and iron losses. It results the lagging power factor due to the inductive coil. So electronic ballast is used to perform the PFC for stable operation in high frequency. In real time application the ballast circuit requires peak current that leads to high crest factor which minimize the lamp life. Also the disadvantage in electronic ballast is, the occurrence of more spikes in a line current. However, mitigating of harmonic distortion caused by lamps is very difficult on the distribution system.

INTRODUCTION

from the utility side caused high energy consumption. To overcome these disadvantages, converter topology is implemented which single switch controlled by the PWM block. This proposed topology reduces the voltage stress and also avoids ripple current. By using Full bridge inverter the output voltage of lamp get decreases hence the half bridge inverter is proposed in the circuit for the high output voltage.

A. DC-DC Converter Topology
Electronic Ballast circuit consists of bridge rectifier, with capacitor followed that the resonant inverter produces a high ignition voltage. Moreover, due to an unstable current resulting a high distortion with low power factor. Power quality issues are reduced by reducing the various DC-DC converter topologies. The problem can be resolved by two stages:

- One is converting the AC mains voltage to regulate DC voltage and another one is to convert regulated DC voltage to AC

BUCK BOOST CONVERTER

The proposed electronic ballast consists of a buck boost converter with a resonant inverter which provides a constant ignition voltage. The half bridge inverter produces a square wave voltage and is fed to the lamp to the LC network for filtering the higher order harmonics. For reducing the switching losses, the switching frequency is kept more than the resonant frequency to achieve zero voltage switching. By operating the converter in DCM (Discontinuous mode Operation) the current reaches peak value which may affect the lamp[1]. To avoid that, the converter operates in a CCM mode with control loop using the PI controller to maintain constant DC voltage as source. Two switches are required while cascading the buck and boost converter[2] which results in switching stresses in the circuit. Therefore, in the proposed topology single switch converter topology is used to perform for reducing their stress.

[Fig.1. Power consumption Vs Lumen]

In the existing system, electronic ballast the switching times of the rectifier and filter distorts the sinusoidal input current with the input current which produces a high magnitude of lower odd harmonics. This result in the large amount of reactive power
Fig. 3 Circuit diagram for electronic ballast

For the input source the normal sinusoidal input voltage is applied to amplitude $V_m$ and frequency of 50Hz.

$$V_S = V_m \sin \omega t$$  \hspace{1cm} (1)

Duty cycle for the continuous conduction mode is

$$V_{dc} = \frac{D}{1-D} \frac{V_i}{n}$$  \hspace{1cm} (2)

$$L = \frac{1}{2} \frac{V_{dc}}{f_{SW}}$$  \hspace{1cm} (3)

A. PI Controller

The DC output voltage of the converter is compared with the set reference voltage of $V_{dc*}$ and the sampling period is given to the PWM generation for generating the gate pulse to the switch $S$.

$$V_{V} = V_{dc} = V_{dc*} \quad (5)$$

$V_{dc*}$ is the reference voltage given to the PI controller

B. Design of Resonant Circuit Parameter

For the steady state operation the resonant inverter is used in the circuit. It consists of resonant inductance $L$, blocking capacitor $C_b$ used to block the DC component which is present in the output inverter and $R$ is the resistance for fluorescent lamps.

$$Q = \frac{\omega L}{R_{lamp}} \quad (6)$$

$$R_{lamp} = \frac{V^2}{P_{lamp}} \quad (7)$$

$$L = \frac{1}{\left(\frac{V_p}{R_{lamp}} + \frac{V_p}{R_{lamp}}\right)} \omega^2 \quad (8)$$

Modes of operation

While operating the buck boost converter, consider the switching frequency is higher than the line frequency.

Mode 1:

At the time to diode $D_1$ start to conduct and the DC bus capacitor gets charged during this interval.

Mode 2:

At the time $t_1$ switch $Q_2$ in the inverter got turned on and meets the Zero Voltage Crossings which allow the DC capacitor to discharge to the $R_{lamp}$. The resonant inductor current changes up to the time $t_2$.

Mode 3:

At the time $t_2$, diode $D$ started Conduct allow Resonant Current to the lamp. During this interval switch $S_1$ in the converter also turns on and provide an output voltage to the inverter which turns the switch $Q_1$ operated the lamp in steady state.

SIMULATION RESULTS

The Buck Boost converter is designed using the MATLAB-Simulink circuit with 220 V of RMS voltage which is shown in fig. 5.
For the input voltage of 220V rms value the ripples in the current is reduced by adding the inductor in the input voltage source. This inductor avoids flickering in the ballast circuit.

![Fig.8. Gate pulse signal for proposed system](image)

By using PI controller the converter voltage is compared with the error signal and given to the PWM block which generates the gate pulse signal shown in the fig.8 for operating the single switch converter.

![Fig.9. THD analysis of proposed system](image)

From the analysis of above fig.9 the harmonics are reduced by using a buck-boost converter and it avoids the interference in the distribution system.

**CONCLUSION**

In the proposed topology the harmonics are reduced to 15% using a buck boost converter and the power factor is improved to 0.98. By using PI controller the output voltage is maintained constant for the ignition of the lamp. By using the Resonant inverter the zero voltage switching is achieved, which reduces the switching losses. Therefore the drawbacks in the conventional circuit are reduced by using the converter topology.

**REFERENCES**


