POWER FACTOR CORRECTION OF ELECTRONIC BALLAST FOR FLUORESCENT LAMPS BY BOOST TOPOLOGY

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Abstract: This paper provides analysis among Power Factor Correction of electronic ballast on Boost topology with high power factor, employing the same switch for inverter and power factor correction stage. The analyses done are based on experimental results. A commercial electromagnetic ballast (EMB) is tested to provide a comparison with implemented electronic ballasts. The features of topology are shown through the discussion of their advantages and disadvantages. The electronic ballasts are made for two 40-W fluorescent lamps at 50-kHz switching frequency and for a 110-Vrms 60-Hz utility line.

Index Terms: Power Factor Correction, Electronic Ballast, Fluorescent Lamps, Boost Topology. (Keywords)

INTRODUCTION

All Lighting ballast is a piece of equipment required to control the starting and operating voltages of electrical gas discharge lights. The term lighting ballast can refer to any component of the circuit intended to limit the flow of current through the light, from a single resistor to more complex devices. Ballast is used to perform the following two functions:

1. Provide the starting kick.
2. Limit the current to the proper value for the tube you are using.

In the old days fluorescent fixtures had a starter or a power switch with a 'start' position which is in essence a manual starter. Some cheap ones still do use this technology.

Ballasts must generally be fairly closely matched to the lamp in terms tube wattage, length, and diameter. This paper present performance analysis and simulation of single stage high-power-factor (HPF) electronic ballast with boost topology for fluorescent lamps which require reduced number of power switches.

PROPOSED BOOST TOPOLOGY OF ELECTRONIC BALLAST

Over here a power factor corrected topology with constant dc link voltage is proposed for an electronic ballast. The power factor correction (PFC) converter improves the input power factor nearly close to unity and regulates the dc voltage.
Here the Figure-1 shows the schematic of the proposed Boost PFC electronic ballast, which consists of a PFC converter and a lamp driving dc-ac converter. The ac-dc converter achieves power factor correction (PFC) and the dc-ac converter supplies high frequency voltage to the fluorescent lamp.

In proposed electronic ballast the selection of a proper converter is made based upon the following guidelines:

- An energy storage element is used between a PFC converter and a lamp driving dc-ac converter to prevent the lamp current from being modulated by the line voltage. For this purpose a dc capacitor is preferred over an inductor due to its lesser cost and size.
- A lamp-driving dc-ac converter is selected to be a voltage-fed inverter to save filter components.
- Low source voltage is needed to boost-up for generating a high voltage to ignite lamp without the need of a boost-up transformer.

**ANALYSIS AMONG POWER FACTOR CORRECTION OF ELECTRONIC BALLAST ON BOOST TOPOLOGY**

Following considerations are made to analyze the proposed topology of electronic ballast.

1. At the time of starting, the fluorescent lamp behaves as an open circuit and during steady state operation it is considered as a pure resistor.
2. As compared to the lamp resistance the filament resistance is neglected and switching devices are considered ideal switches.
3. The dc blocking capacitor $C_b$ is much larger than the resonant capacitance $C_p$ so that its voltage ripple is negligible.

**Boost Converter Circuit**

Here in Figure-2 the average output voltage is more than the input voltage $V_d$. The filter capacitor is assumed to be high so that the output voltage is more of less constant. When the switch in ON, Inductor current is rising and When the switch in OFF, Inductor current is falling.

This Technology of a new electronic ballast based on boost topology of high power factor for compact fluorescent lamps. The Topology can be treated as two independent converters: the inverter & power factor correction stage. This converters can be designed separately.
In the same manner analysing the comparison of different ballasts as follows:

<table>
<thead>
<tr>
<th>Magnetic Ballast</th>
<th>Hybrid Ballast</th>
<th>Digital High Frequency Electronic Ballast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic ballast are “Core &amp; Coil” Electromagnetic Ballast.</td>
<td>Hybrid Ballast use a magnetic core coil transformer &amp; an electronic switch for electrode heating circuit.</td>
<td>This ballast replaces the core &amp; coil Transformer with electronic components</td>
</tr>
<tr>
<td>Magnetic Ballast Operate at line Frequency 60 Hertz</td>
<td>Like Magnetic Ballast, Hybrid Ballast operate Fluorescent Lamps at line Frequency of 60 Hertz.</td>
<td>Digital High Frequency Electronic Ballast operate lamps at 20-60 kHz.</td>
</tr>
<tr>
<td>Magnetic Ballast Have Greater Power Losses</td>
<td>Hybrid Ballast disconnect the electrode heating Circuit after they start the lamps. That’s why they save more power comparison to Magnetic Ballast</td>
<td>The Electronic ballast have half (1/2) the Power Loss comparing to other ballasts.</td>
</tr>
<tr>
<td>A Lamp Ballast System Consisting of a Magnetic Ballast and two 32-W T8 Lamps requires approximately 70W.</td>
<td>They save approximately 9W when operating two 32-W T8 Lamps compared with magnetic ballasts.</td>
<td>High Frequency Electronics Ballast reduce the wattage by 10-15 W compared with other ballast operating two 32-W T8 lamps.</td>
</tr>
<tr>
<td>Magnetic Ballast are bit cheaper &amp; Cost effective</td>
<td>Hybrid Ballast cost more than magnetic ballast but less than electronic ballasts.</td>
<td>Electronic Ballast are a bit higher in Cost compared to both Magnetic &amp; Hybrid Ballast</td>
</tr>
</tbody>
</table>

**TABLE-1**

**SIMULATION CIRCUIT FOR BOOST TOPOLOGY BASED ELECTRONIC BALLAST**

The Matlab model of the proposed electronic ballast is developed as shown in figure in which the lamp is considered as a resistor at high frequency. The PFC topology is modeled in Matlab-Simulink model using PI (Proportional Integral) controller with current multiplier approach. The design values of the components obtained from various design equations are appropriately selected to have desired power quality at the AC mains.
A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).

**EXPERIMENTAL RESULTS**

The objective of the modeling and simulation is to validate the design of proposed electronic ballast which has improved power factor and low THD. Experimentally Power Factor obtained is 0.989 & harmonics graphically obtained are:

**Comparison of Implemented & Previously Obtained Results**

<table>
<thead>
<tr>
<th>SR No.</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Types of tubes Compatible – T4, T5, T8, T12</td>
</tr>
<tr>
<td>2.</td>
<td>Frequency of Boost Topology: - 100kHz</td>
</tr>
<tr>
<td>3.</td>
<td>Frequency of Half Bridge Rectifier is : -40kHz</td>
</tr>
<tr>
<td>4.</td>
<td>Voltage of Electronic Ballast:- 100V</td>
</tr>
<tr>
<td>5.</td>
<td>Current = 0.28A or 280mA</td>
</tr>
</tbody>
</table>

**TABLE-2**

**CONCLUSION**

A high power factor electronic boost ballast with constant dc link voltage has been designed, modeled and simulated to study its behavior. The dc link voltage has been maintained...
constant, independent of changes in the ac input voltage. With an appropriate design of the resonant converter, the lamp current has been found close to the rated value.

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REFERENCES