Design and Implementation of Maximized Efficiency and Power Factor of Electronic Ballast for Fluorescent Lighting Application

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Abstract- Electronic Ballast is used for the Compact fluorescent lamp (CFL).The present work focus on development of Electronic Ballast having almost unity power factor (UPF) improved power quality. The electronic ballast consists of a PFC (power factor corrected) Boost converter, which operates in discontinuous conduction mode (DCM), and a high frequency DC-AC inverter. It overcomes the drawback of operating the boost converter in open loop by operating the boost converter in closed loop to provide constant power to the load within in the specified ratings irrespective of the changes in the load. It uses less number of inductors and capacitors which reduces the cost of the total equipment, especially at high voltage ratings capacitor and inductor cost becomes more and overcomes the drawback of high cost at higher voltage ratings. HID lamps are sensitive to voltage supply fluctuations producing an effect on human visual perception, known as flicker. The fluctuations are typically caused by the repetitive variation in the power consumed by loads, or by the connection and disconnection of significant loads.

The existing method comprises hard switching boost converter and full bridge inverter, its drawback are less efficiency (90.4%) at boost converter operation and less power factor (.88) and total harmonic Component (7.24%) for full bridge inverter operation, to overcome this issue are implemented by soft switching boost converter and boost inverter as the proposed method. From proposed electronic ballast to obtain the total harmonic component (1.52%) for full bridge inverter.

Keywords— Boost inverter, Boost converter, Electronic ballasts, flicker, Power factor correction

I.INTRODUCTION

Electronic ballasts for HID (High Intensity Discharge) lamps are gaining market share since they are focused on achieving energy savings, reduction in utility line harmonic content and reactive power, as well as implementing dimming control and some other actions of interest in lighting applications. Electronic Ballast is used for the Compact Fluorescent lamp (CFL). The present work focus of Electronic Ballast having almost unity power factor (UPF) improved power quality. The electronic ballast consists of a PFC (power factor corrected) Boost converter, which operates in discontinuous conduction mode (DCM), and a high frequency DC-AC inverter. It overcomes the drawback of operating the boost converter in open loop by operating the boost converter in closed loop to provide a constant power to the load within in the specified ratings irrespective of the changes in the load .When the lamps are dimmed out to a lower light level, the density of Electrons will drop significantly, which would result in visible striation. Moreover, power imbalance exists between the power factor correction semi stage and the ballast semi stage, which usually results in a high dc-link voltage and might damage the switching devices. Strategies for suppressing the high dc-link voltage and eliminating the effect of striations occurring in a fluorescent lamp are therefore proposed. In addition, an improvement on the jump phenomenon of lamp luminous output when it is controlled by varying the switching frequency will also be proposed. A traditional design methodology is the use of buck inverter. One of the characteristics of the most classical inverter is that it produces an AC output instantaneous voltage always lower than the dc input voltage. Thus if an output voltage higher than the input one is needed, a boost dc-dc must be used between the dc source and the inverter .The light flickering in 150 W HPS lamps caused by utility disturbances is measured and compared to the effect in the lamps when they are supplied by traditional electromagnetic ballast. The results are normalized using the effect of the disturbances measured on a filament lamp to reject possible disturbances caused by the acquisition equipment. The light variation is compared to the standards that make reference to acceptable or non-acceptable flickering effects. Results are considered to introduce new design criteria in electronic ballast.

II. CONVENTIONAL METHOD

The conventional method comprises hard switching boost converter and full bridge inverter, its drawback are less efficiency (90.4%) at boost converter operation and less power factor (.88) and total harmonic Component (7.24%) for full bridge inverter operation, to overcome this issue are implemented by soft switching boost converter and boost inverter as the proposed method.

The conventional method as shown in figure 1.

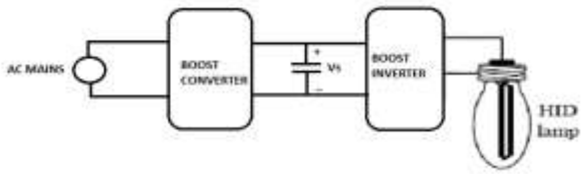

Figure 1: The Block diagram of Existing method

III.PROPOSED METHOD

The proposed method operates with soft switching DC-DC boost converter and boost inverter (DC-AC) as illustrated below.

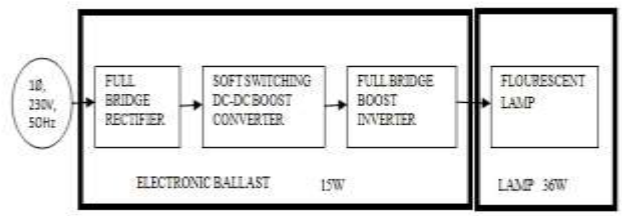

Figure 2: Block diagram of proposed Electronic Ballast

The proposed system consists of soft switching dc-dc boost converter and Full Bridge Boost Converter.

IV.SOFT SWITCHING DC-DC BOOST CONVERTER

A converter topology with single switch and switching strategies to make the switch on at zero current and off at zero voltage at the given switching time with charging and discharging modes

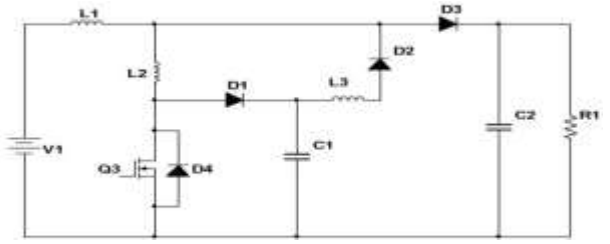

Fig .3 Soft Switching DC-DC Boost Converters

The circuit diagram of the proposed converter with soft switching scheme is shown in Figure .3. The switch S_1, L_1, D_3 and C_2 are the main boost converter components, while R represents the resistive load on the converter. Inductor L_2, L_3, D_1, D_2 and C_1 form the auxiliary circuit for accomplishing the soft switching of S_1. Inductors L_2 and L_3 are much smaller than L_1 and C_1 is much smaller than C_2. There are seven modes of operation. The duration of modes 1, 2, 5 and 6 being quite small i_{L1} and Vout are assumed constant at I_1 and V_1 for modes 1 and 2, and I_2 and V_2 for modes 5 and 6 respectively.

MODE 1: This mode begins with the turn on of S1, at zero current at t_0.The expressions are,

$$I_{L2}(t)=V_1/i_2 \quad (1)$$

$$V_{c1}(t_1)=[V_1-V_{C1}](t_0)][1-\cos w_1 t]+V_{C1}(t_0) \quad (2)$$

$$i_{L3}=[V_{C1}(t_0)-V_1](\sin w_1 t)/(w_1 L_3) \quad (3)$$

where $w_1=1/\ (L_3 c_1)$

When D3 stops conducting and this mode comes to an end.

MODE 2: The initial conditions on L_3, L_2 and C_1 are V respectively, attained at the end of mode 1.The expressions are,

$$V_{C1}=-v_{C1}(t_1)\,[1-\cos w_2 t] +i_{L2}(t_1)/\,(w_2 c_1)\sin w2-v_{C1}(t_0) \quad (4)$$

$$I_{L3}=v_{C1}(t_1)/w_2(L_2+L_3)\sin w_2 t+i_{L3}(t_1)\cos w_2 t \quad (5)$$

$$I_{L2}(t) =v_{C1}/w_2\,(L_2+L_3)\sin w2t+i_{L3}(t_1)\cos w2t+i_1 \quad (6)$$

Where,
$w_2=1/\ ((L_2+L_3)\ Chi)$

This mode comes to an end when v_{c1} reaches zero at t_2.

MODE 3: The initial conditions on are zero the expression for i_{L3} is

$$I_{L3}(t)=((-v_s L_2)/(L_1 L_2 +L_2 L_3+L_3 L_1))(t) +i_{L3}(t_2) \quad (7)$$

MODE 4: In this mode current buildup in L_1 and L_2, and V_{out} (t) are governed by the equations as follows.

$$I_{L1}(t)=i_{L2}(t)=V_s/(L_1 + L_2)+ i_1 \quad (8)$$

$$V_{out}(t)=V_1 e^{(1/RC)} \quad (9)$$

This mode comes to an end when S_1 is turned off at zero voltage at t_4

MODE 5: This mode begins with the turn off of S_1 at zero voltage at t_4.The expressions are,

$$V_{c1}(t) =V_2\,(1-\cos w_3 t) + (i_2/w_2 c_1)\sin w_3 t \quad (10)$$

$$I_{L2}(t) = [V_2 c_1 \sin w_3 t-i_2\,(1-\cos w_3 t)] +i_2 \quad (11)$$

$$I_{L3}(t) = (L_2/L_2+L_3)\,[-V_{2C1} w3t + i_2\,(1-\cos w_3 t)] \quad (12)$$

Where,
$w_3=1/\ ((L_2 L_3)/(L_2 +i_3))c_1$

This mode ends when i_{l2} reaches zero at t_6

MODE 6: In this mode i_{L3} reduces to zero. This mode comes
To an end at t6 when i_{L3} become zero. The expression for i_{l3} and v_{c1} for this mode is

$$i_{L3}=((V_{C1}(t_5)-V_2)/L_3 w_1)\sin w_1 t+i_{L3}(t_5)\cos w_1 t \quad (13)$$

$$V_{C1}=[V_{C1}(t_1)-V_2][\cos w_1t-1]((i_{L3}(t_5)/w_1C_1))\sin w_1t \quad (14)$$

MODE 7: In this mode i_{L2}, iL3 are zero. This mode comes to an end at t_7 when S_1 is turned on at zero current. This is the Normal mode of the boost converter. The expressions are,
This mode comes to an end at t_3 when i_{L3} reaches zero at t_3

$$V_{out}(t)=e^{-at}[A\ \sin w_4t + B\sin w_4t]+V_s$$

$$i_{L1}(t)=(V_{out}(t)/R)+e^{-at}[((-BC_2+AC_2w_4t)\cos w_4t-(AC_2+BC_2w_4)\sin w_4t) \quad (16)$$

where,

$\alpha= (1/2RC_2)$ $\quad w_4=1/\ (L_1C_2)$

$A=L_2/\ (w_4C_2)-V_2/\ (Rw_4C_2)\ +\alpha\ (V_2-V_5)/w_4$

$B=V_2-V_s$

This are the modes of soft switched boost converter operation for zero current turn on and zero voltage turn off.

V. BOOST INVERTER

Let us consider two dc-dc converters feeding a resistive load R as shown in Fig. 4.The two converters produces dc-biased sine wave output such that each source only produces a unipolar voltage.

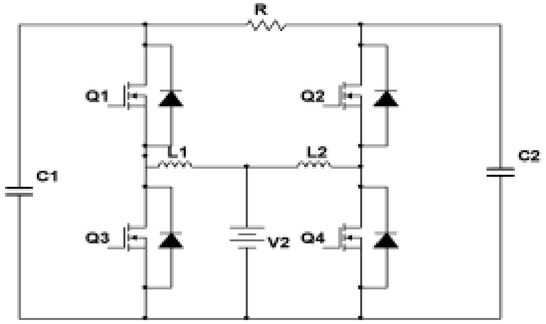

Figure 4: Circuit Diagram of Boost Inverter

The modulation of each converter is 180 degrees out of phase with the other so that the voltage excursion across the load is maximized. Thus, the output voltage of the converters are described by

$$V_a=V_{dc}-\ V_m\sin wt \quad (17)$$

$$V_b=V_{dc}-V_m\sin wt \quad (18)$$

Thus, the output voltage is sinusoidal as given by

$$V_O=V_a-V_b=2V_m\sin wt \quad (19)$$

Thus, a dc bias voltage appears at each end of the load with respect to ground, but the differential dc voltage across the load zero.

Principle of Boost Inverter

Each converter is a current bidirectional boost converter as shown in Fig 4. The output of the inverter can be controlled by one of the two methods: (1) Use a duty cycle D for converter A and a duty cycle of (1- D) for converter B. (2) Use a differential duty cycle for each converter such that each converter produces a dc-biased sine wave output. The second method is preferred and it uses controllers A and B to make the capacitors voltage v_a and v_b follow a sinusoidal reference voltage.

VI.SIMULATION RESULT

The simulation parameter of power electronic devices and passive devices as in MATLAB simulation

Parameters Valve of Boost Converter

Input =12V

- S=IGBT Switch of Boost Converter
- D_1 –D_3=Freewheeling Diode
- L_1=1μH,
- L_2=L_3=10μH,
- C_1=1mF,
- C_2=10pF,

Parameters Valve of Boost Inverter

- S_1-S_2 =IGBT Switches Of Boost Inverter
- Q_1-Q_4=IGBT Switches Of Boost Inverter
- D_1-D_6=Freewheeling Diodes
- L_1,L_2=10μH
- C_1,C_2=220μF
- R_{LOAD}=200Ω
- O_{utput}(Boost Converter)=56v
- O_{utput}(Boost Inverter)=120V

Simulation Diagram of Boost Inverter

The simulation diagram of the proposed boost inverter has DC output of boost converter fed boost inverter circuit which input voltage ranging of 56V. The low voltage of boost converter has boosted up to voltage 120V and also DC-AC conversion takes place. Resistive load is used in this boost inverter circuit.

From the simulation diagram of boost inverter circuit, the output voltage obtained from the boost inverter circuit is ACVoltage. Fig.4 shows the output voltage waveform of the boost inverter. The voltage and current parameter are shown in x axis and time in y axis respectively.

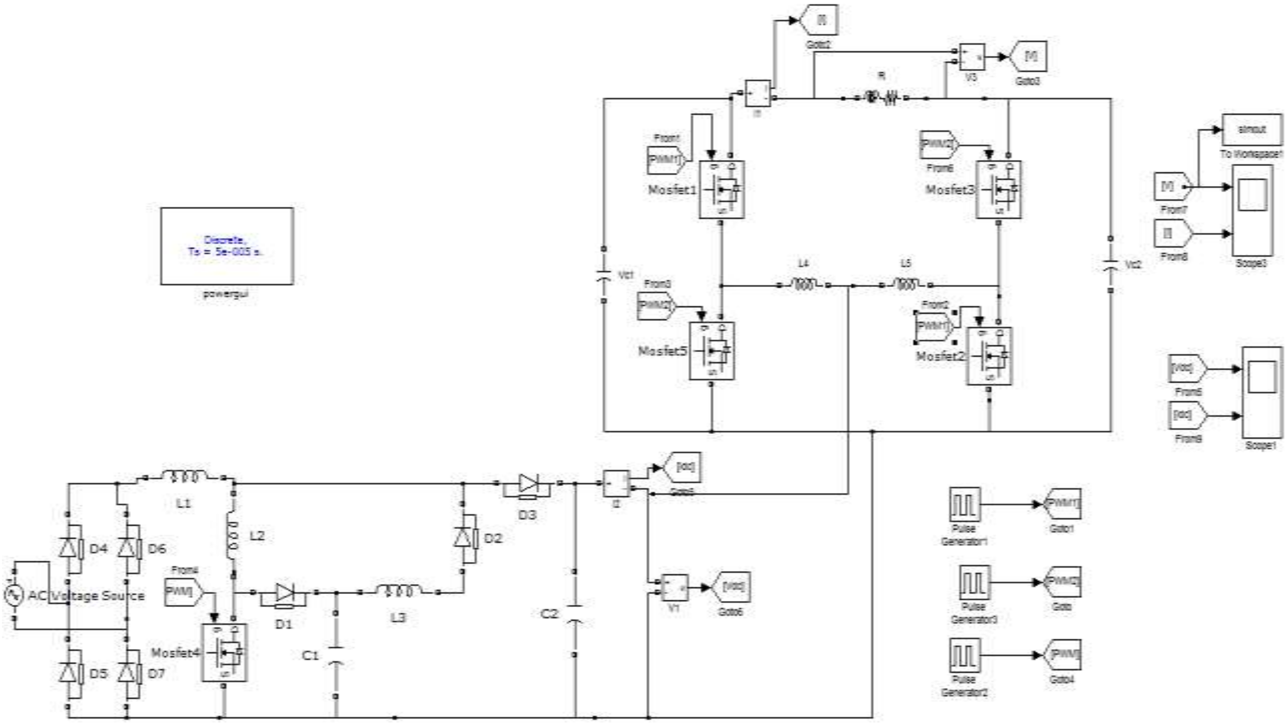

Fig. 5 .Proposed Simulation Method of Electronic Ballast

The simulation diagram of the proposed boost inverter has DC output of boost converter fed boost inverter circuit which input voltage ranging of 56V. The low voltage of boost converter has boosted up to voltage 120V and also DC-AC conversion takes place. Resistive load is used in this boost inverter circuit.

From the simulation diagram of boost inverter circuit, the output voltage obtained from the boost inverter circuit is AC voltage. Fig.7 shows the output voltage waveform of the boost inverter. The voltage and current parameter are shown in x axis and time in y axis respectively.

The DC input in boost converter circuit to boost up the voltage and then low voltage of boost converter circuit applied to boost inverter circuit to obtain 120V AC .Resistive load is used as per application purpose. Its voltage and current waveform is shown in fig.6

The simulation diagram of the proposed boost converter. It consist of DC input voltage ranging 12V is fed to boost converter and boost inverter to boost up the voltage level upto step up to 120v .Here capacitor acts as a filter and resistor acts as resistive load.

From the simulation diagram of boost inverter circuit, the output voltage obtained from the boost inverter circuit is AC voltage. The sinusoidal voltage is produced that the two boost converter are operated 180^0 out of phase. The load is connected differentially across the converters.

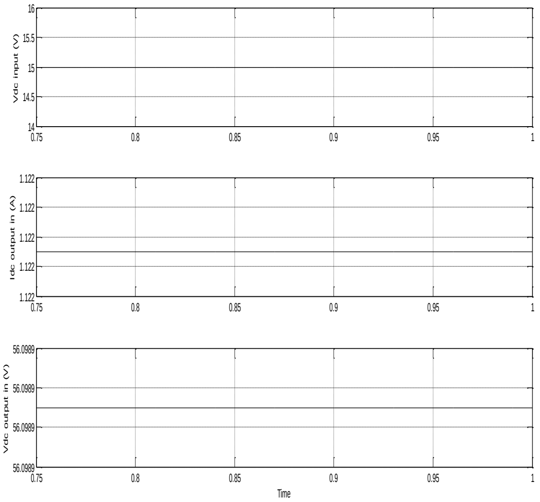

Figure 6 Output Waveform of Boost Converter

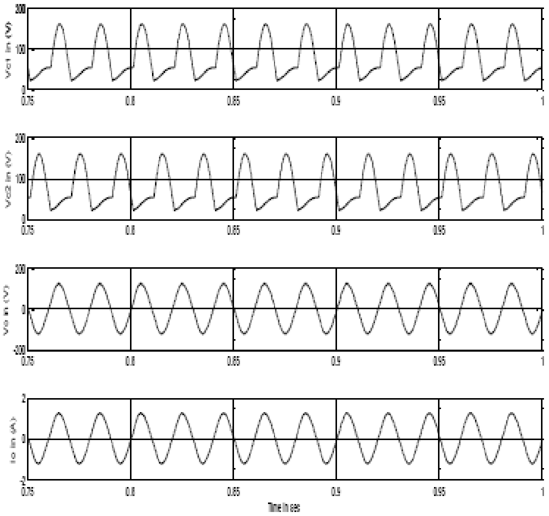

Fig 7:Output Waveform of Boost Inverter

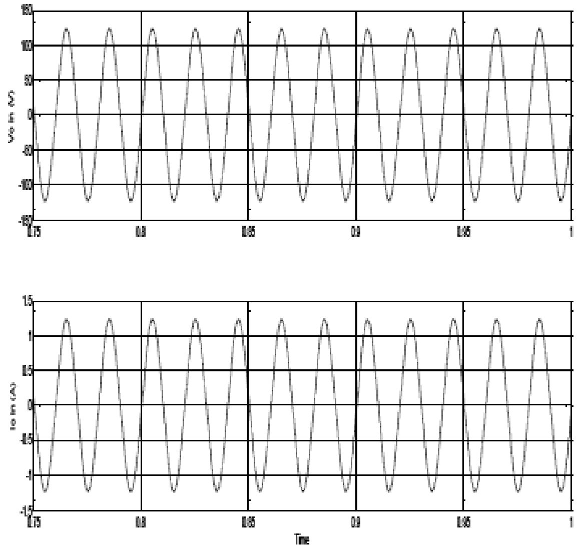

Figure 6 Output Waveform of Boost Converter

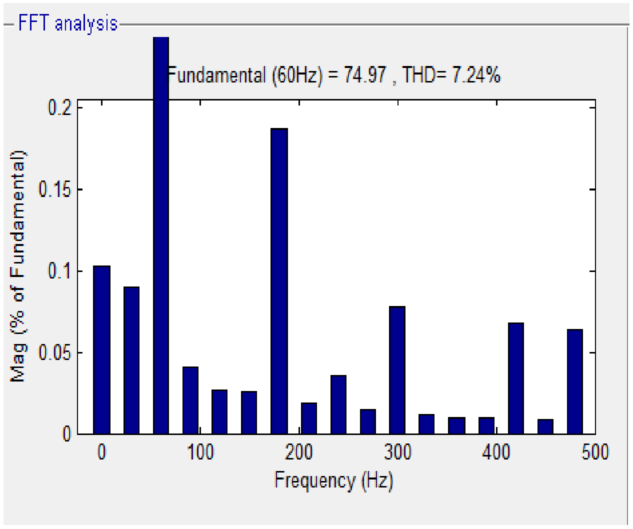

Fig 9: Total Harmonic Distortion of Conventional Method

The voltage and current parameters shown in x axis and time in y axis respectively. The overall simulation diagram of the proposed is shown in the Fig.5   Total Harmonic Distortion of THD value of conventional 7.24% is shown in fig 9.

The table explains comparison between conventional method and Proposed Method.

CONTENT	EXISTING METHOD	PROPOSED METHOD
CONVERTER	Hard Switching converter	Soft switching converter
PFC	Active PFC	Passive PFC
THD RESULTS	7.24%	1.52%
INVERTER	Boost Inverter	Full bridge inverter

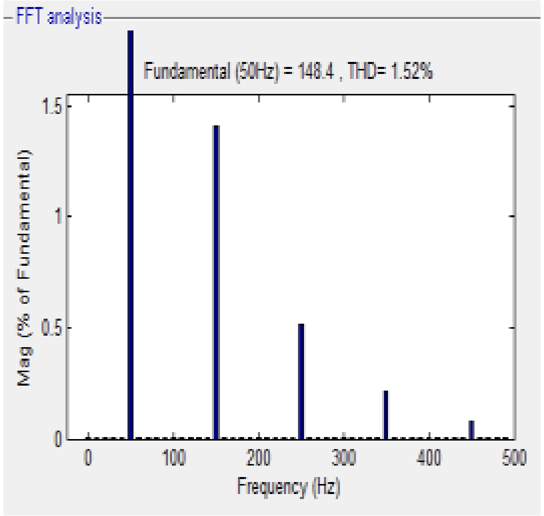

Fig 10: Total Harmonic Distortion of Proposed Method. The

The Total Harmonic Distortion of Converter reduced to 1.24% is shown in fig 10.

VI.CONCLUSION

This paper investigates the possibility to optimize both the efficiency and the power factor of energy conversion systems which include power electronic converters. The values of these important power quantities depend on different parameters, such as the switching technique and the switching frequency of the power electronic elements. In this paper to implemented a new type dc to ac inverter. We use IGBTs as active switches which operate at fixed frequency. Here we use different linear and nonlinear loads. Our simulation result is not completely coping with the proposed theory. Because in ours simulation we used the ideal conception. There is a vast scope for future work about this project. Here we use SPWM to control the IGBTs which operate at high frequency and pulse width change automatically.

Low-frequency magnetic ballasts will consume power even after the lamps have failed. Most high frequency electronic ballast are designed with built in circuitry to cut out when the lamps are not operating .Finally electronic ballasts run on AC or DC and can be used to drive several lamp types.

The dimming capacity in electronic ballast for fluorescent lamps has been quickly increased due to high potential of energy saving and the comfort to users but it represents new challenges in the design of electronic ballast.

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