



Hardware Implementation of a Resonant Converter For LED Application

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ABSTRACT :

This work presents a high-efficiency resonant converter for LED street-lighting applications. The developed topology integrates a Totem-Pole Boost PFC stage with an LCCL resonant network, enabling improved input power quality and reduced switching-related losses. Soft-switching techniques such as Zero Voltage Switching and Zero Current Switching are employed to reduce switching stress and support efficient operation of the power switches. The proposed converter provides regulated current to the LED load while minimizing conduction and switching losses. The resonant operation also helps to reduce electromagnetic interference and improve system reliability. The proposed topology provides an efficient and compact solution for modern LED lighting applications.

Keywords: LCCL Resonant Converter, PWM, LED Lighting, Arduino UNO, Switching Loss Reduction, Soft Switching, ZVS.

Introduction

The adoption of LED technology in street lighting is mainly associated with its reduced energy requirement, extended service life, and comparatively low maintenance needs. The LED driver plays an important role in providing a stable current to the load. The use of multiple power-processing stages in conventional LED drivers can increase the overall circuit complexity and associated conversion losses.

To overcome these limitations, resonant and bridgeless converter structures can be used. In this work, a bridgeless resonant converter combining a Totem-Pole Boost PFC stage and an LCCL resonant network is proposed for LED lighting. The topology provides power-factor improvement, constant LED current, and reduced switching stress through soft-switching operation.

2. Proposed System

The proposed system combines a Boost PFC converter with an LCCL resonant converter in a single-stage structure. The Totem-Pole section improves input power quality and controls the input current, while the LCCL network provides resonant energy transfer to the LED load. The bridgeless structure reduces the conduction path and eliminates the conventional bridge rectifier. Soft-switching techniques, including ZVS and ZCS, reduce switching stress and losses. The output rectifier converts the high-frequency resonant output into regulated DC current for stable LED operation. Thus, the proposed system provides a compact and reliable solution for LED street-lighting applications. The overall configuration of the proposed system is illustrated in Fig. 1.

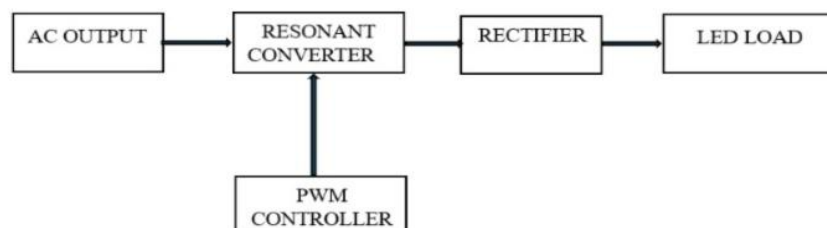


Fig. 1. Block Diagram of the Proposed System

2.1 Resonant Converter Circuit

The developed topology integrates the boost PFC section with an LCCL resonant network to transfer regulated power to the LED load. The main components are the input LC filter, boost inductor L_B , switches S_1 and S_2 , diodes D_1, D_2, D_{01}, D_{02} , resonant inductors L_{r1}, L_{r2} , resonant capacitors C_{r1}, C_{r2} , DC-link capacitor C_B , and output capacitor C_o . The Totem-Pole stage improves the input power factor, while the LCCL network provides regulated output current with soft switching.

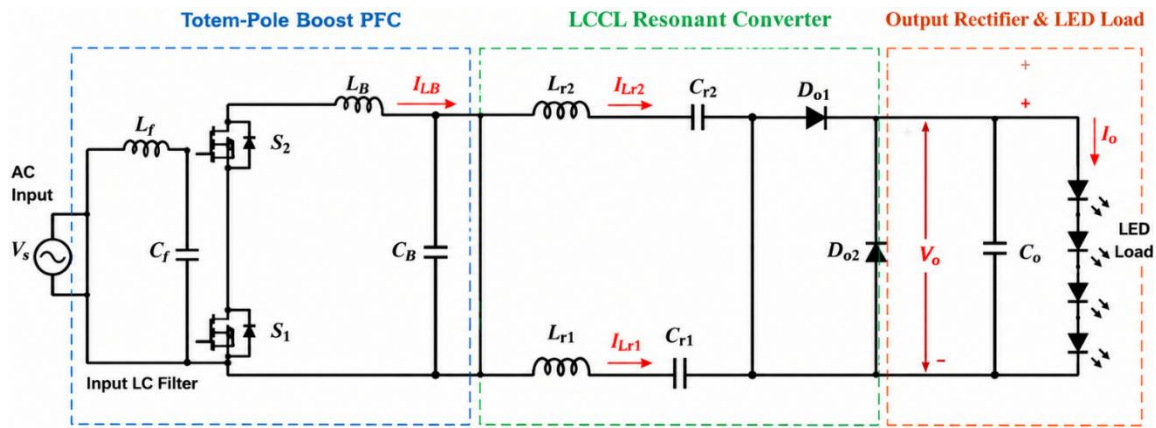


Fig. 2. Circuit Diagram of the Proposed Resonant Converter

As illustrated in Fig. 2, The proposed converter operates in eight modes during one positive half-line cycle. In Modes 1–2, conducts and the boost inductor stores energy, followed by charging and discharging of the switch capacitors. In Modes 3–4, conducts and resonant energy transfer occurs through L_{r1}, L_{r2}, C_{r1} and C_{r2} , while the output diodes transfer energy to the LED load. In Modes 5–6, the LCCL network continues resonating and maintains output-current transfer. In Modes 7–8, turns OFF and turns ON under ZVS, completing the switching cycle. The Totem-Pole stage provides power-factor correction, the LCCL network regulates the LED current, the resonant components enable soft switching, and the output capacitor maintains smooth load current.

3.Design of Proposed System

The proposed system is designed for LED street-lighting applications over the required input and load ranges. It includes the selection of resonant components, transformer, switches, and control circuits for stable operation and soft switching.

The design Specification for these converter are given $V_{in}=24V$, $V_o=13.4V$, $F_s=200KHZ$

Design of Inductor

The proposed converter uses three inductors: the boost inductor and two resonant inductors and The boost inductor is selected as to maintain DCM operation. The resonant characteristic impedance is selected as Therefore,

$$L_{r1} = \frac{1}{(2\pi f_s)^2 C_r} \quad 3.1$$

$$L_{r1} = \frac{1}{(2 \times 3.14 \times 179000)^2 \times 20 \times 10^{-9}}$$

$$L_{r1} = \frac{1}{(1124120)^2 \times 20 \times 10^{-9}}$$

$$L_{r1} \approx 39.7\mu H$$

$$\text{since } L_n = \frac{L_{r2}}{L_{r1}} = 1$$

$$L_{r2} = L_{r1} = 39.7\mu H$$

Design of Capacitor

The proposed LCCL resonant network uses two resonant capacitors and the primary resonant capacitor is calculated using the selected characteristic impedance and switching frequency:

$$C_r = \frac{1}{2\pi f_s Z_r} \quad 3.2$$

$$C_r = \frac{1}{(2\pi f_r)^2 L_r}$$

$$C_r = \frac{1}{(2 \times 3.14 \times 179000)^2 \times 39.7 \times 10^{-6}}$$

$$C_r = \frac{1}{(1124120)^2 \times 39.7 \times 10^{-6}}$$

$$C_r \approx 20nF$$

Design of Output Capacitor C_o

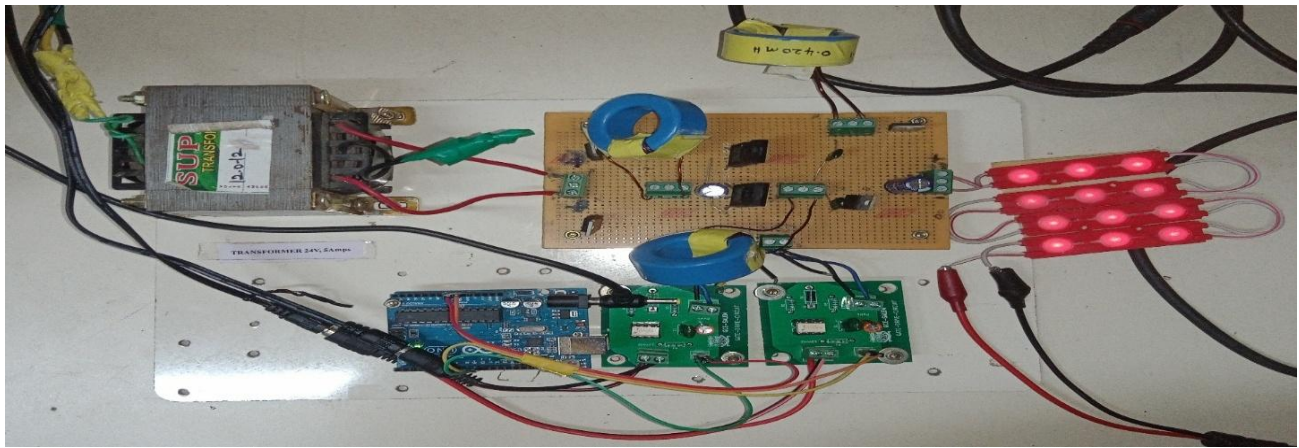
$$C_o \geq \frac{1}{2f\Delta V_0} \quad 3.3$$

$$C_o = \frac{1}{100000}$$

$$C_o = 10\mu F$$

4. Hardware Implementation

A hardware prototype was developed to experimentally evaluate the operation of the proposed resonant converter. The prototype incorporates the power-stage switches, resonant components, transformer, gate-driver circuit, and Arduino UNO-based pulse generation unit. The output to the LED



load. The hardware implementation helps to validate the proposed converter operation and its suitability for LED lighting applications.

1. Step up transformer, 2. converter circuit, 3. Arduino UNO, 4. Gate driver Circuit, 5. LED Load

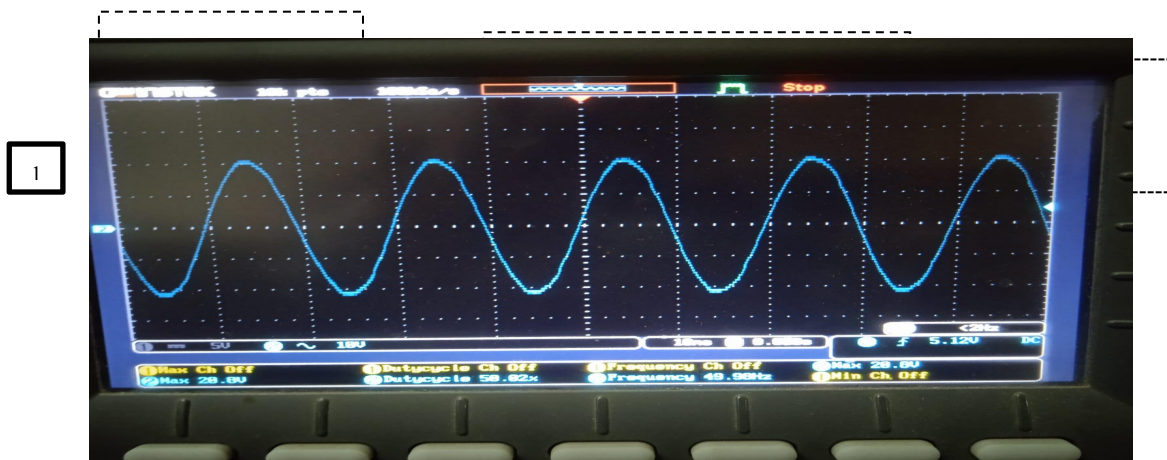


Fig. 3. Hardware Setup

Fig. 4. AC Input Waveform



Fig. 5. Output Gate Pulses



Fig. 6. DC Output Waveform

6. Conclusion and Future Scope

The proposed bridgeless resonant converter with an LCCL resonant network to provide regulated LED current, improved power quality, and reduced switching stress. Soft-switching operation supports reliable and stable LED performance. In future, the system can be extended with renewable energy sources, smart monitoring, advanced control techniques, and modern semiconductor devices to further improve converter performance and reliability.

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