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LED DRIVER WITH POWER FACTOR CORRECTION USING FLYBACK CONVERTER

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ABSTRACT

The project aims to improve energy efficiency and reduce operating costs by incorporating Power Factor Correction (PFC) into a flyback converter for LED drivers. This improves power factor, reducing energy waste and increasing consumption expenses, ensuring more energy is converted into productive work. Traditional flyback converters often suffer from poor power factors, leading to energy waste and higher costs. The project uses a Boost converter in the PFC stage to shape input current and achieve a power factor close to unity, reducing power losses and lowering energy consumption. This solution ensures stable LED lighting performance under varying input voltages and load conditions, benefiting large-scale LED lighting systems.

Keywords— Power Factor Correction (PFC), LED drivers, flyback converters.

I. INTRODUCTION

This study is to investigate the vital role that Light Emitting Diode (LED) technology plays in energy-efficient lighting, having a particular emphasis on the advantages and capabilities of LED drivers that have Power Factor Correction (PFC). These drivers are critical for converting AC power to the necessary DC voltage and current, hence improving energy efficiency. The use of flyback converters in these drivers is highlighted because of their simplicity, compactness, and isolation characteristics. This combination optimizes energy delivery to LEDs while simultaneously ensuring regulatory compliance, making it a long-term option for current lighting applications. The study emphasizes the necessity of improving LED technology to achieve higher energy savings and lower environmental impact in a variety of applications, eventually leading to a more energy-efficient future.

II. LITERATURE SURVEY

2.1 L. CAO et.al. [1] proposed, a new electrolytic capacitor-less LED driver with power factor correction (PFC) function is proposed.

A single-stage topology with an optimized energy-flow channel and increased efficiency is proposed using a linked inductor. With this novel architecture, electrolytic capacitors can be replaced by film capacitors with lower capacitance values and longer lifetimes, extending the lifespan of the LED driver.

2.2 A. Cheng et.al. [2] proposed a novel single-stage LED driver for street lighting applications with high levels of power factor.

The driver integrates a modified bridgeless AC-DC converter with a half-bridge-type LLC DC-DC resonant converter, offering cost-effectiveness, high circuit efficiency, high power factor, low input current ripples, and reduced components count. It supplies a 144W LED street-lighting module.

2.3 Salazar-Perez et.al. [3] proposed a novel high-power-factor electrolytic capacitor-less LED driver based on the use of a ripple port is presented.

The ripple port adds an extra power processing circuit to the converter output, reducing output current and voltage ripples. It includes an extra winding, switch, capacitor, and inductor, injected during low flyback output current.

2.4 J. Garcia et.al. [4] proposed a new topology based on the integration of two flyback converters with different polarities.

The proposed converter enhances efficiency by avoiding full-bridge rectifying stages and using special electronics to handle energy flows in ballasts, a crucial aspect for micro renewable generators in lighting applications.

2.5 M. Soares et.al. [5] presented the study of an off-line flyback-based LED driver with reduced storage capacitance.

Active Ripple Compensation (ARC) is a technique used to minimize converter bulk capacitance in voltage-controlled PWM converters. It reduces filtering capacitance by increasing input current harmonic content. The technique can be fully controlled and theoretically predicted, and requires no additional sensors.

III. PROPOSED SYSTEM

The proposed Power Factor Correction (PFC) converter for LED lighting utilizes a forward converter, flyback converter, and multi-winding transformer for enhanced performance.

The key highlights:

1. **Single-Switch Flyback Converter in Discontinuous Conduction Mode (DCM)**:
   The converter operates in DCM, simplifying design and ensuring electrical isolation between input and output, reducing circuit complexity and component count, making it cost-effective and compact.
2. **Improved Power Factor**:
   The technology is designed to improve the power factor, meeting the growing demand for energy-efficient solutions. By matching the input voltage and current waveforms that are the converter's function decreases power consumption and improves overall system efficiency.
3. **Responsive Control System for Stability and Efficiency**:
   The system incorporates an adaptive control mechanism that responds to changes in input voltage and LED load. The system constantly maximizes efficiency, eliminating energy waste and increasing LED operating lifetime by keeping them within their optimal voltage range.

4. **Wide Applicability in LED Lighting Applications**:
   The design effectively manages fluctuating input conditions, making it suitable for various environments like street lighting, commercial buildings, and residential areas.

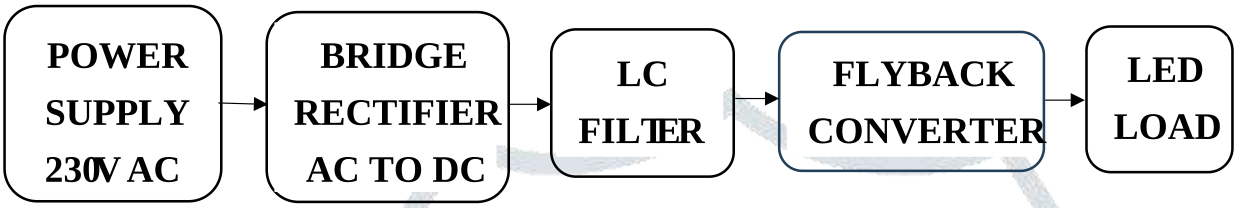

Figure 1 Block Diagram of proposed work

Figure 1 depicts a block schematic of the suggested work, showing the main elements of an LED driver with a flyback converter for PFC. The goal is to convert 230V AC input power into a suitable DC output for LED applications.

SIMULATIONS

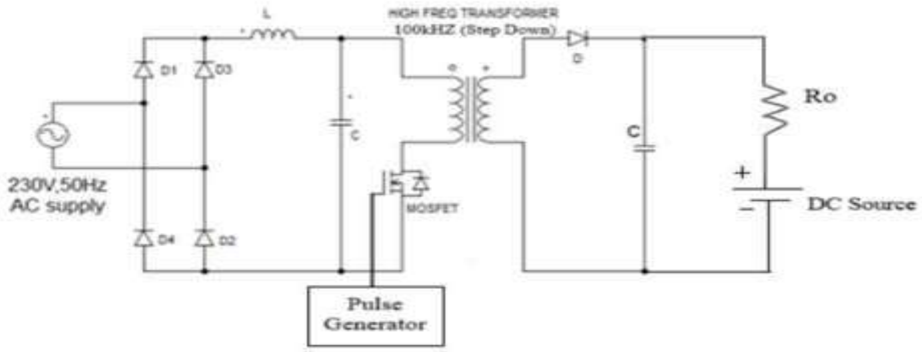

Figure 2 Circuit diagram

In figure 2, The fly back converter system converts a single-phase AC supply into a regulated DC output for powering loads. It uses a diode bridge rectifier to convert the AC input into pulsating DC, which is filtered using an EMI filter. The filtered voltage is directed to a MOSFET, controlled by a pulse generator, for energy transfer. The system ensures efficient energy conversion and isolation, making it ideal for powering electronic devices or LEDs.

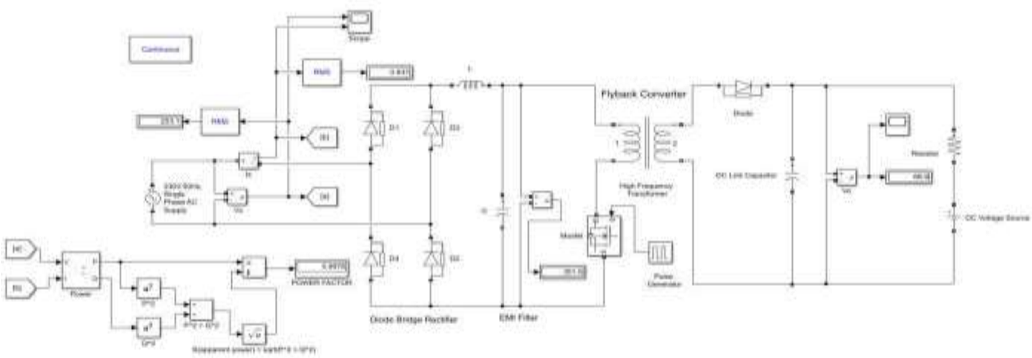

Figure 3 Simulation of LED driver

The simulation circuit in Figure 3 shows an advanced power supply system for LEDs, powered by a single-phase AC input. The AC voltage is converted to pulsating DC through a diode bridge rectifier, smoothed by an EMI filter, and fed into a flyback converter. The converter outputs a regulated DC voltage, ensuring safety and reliability. The system achieves an impressive power factor of 0.9978, indicating efficient operation with minimal reactive power.

Table 1 Without and With Power Factor Correction

S. No	Supply Voltage (V_s)	Without PFC	With PFC
1	160	0.6612	0.8834
2	175	0.7814	0.8894
3	192	0.8114	0.9358
4	205	0.8814	0.9774
5	230	0.9849	0.9978

The "Without PFC" column displays the system's original power factor values at different voltage levels, indicating the efficiency of electrical power utilization before corrective measures are applied, typically due to reactive power.

The "With PFC" column shows improved power factor values after compensation measures, such as capacitor banks, leading to better energy utilization, reduced wastage, improved system efficiency, lower electricity bills, and reduced grid strain.

The system shows progressive improvement in power factor across all voltage levels, approaching unity, and performs better at higher voltages even without compensation.

IV. CONCLUSION

It provides an effective and dependable technique of powering LED lighting systems while maintaining a high power factor. Using a flyback converter topology, this device provides electrical isolation while also producing a regulated DC output suited for LED applications. The inclusion of PFC improves input power quality by combining the input current and voltage. The system is designed to meet current energy regulations, providing energy-efficient and high-performance LED lighting options. The importance of power factor correction in raising both the stability and the effectiveness of LED drivers is demonstrated by this project.

V. FUTURE SCOPE

- Future advances could incorporate modern semiconductor devices like GaN or SiC MOSFETs, which can operate at higher frequencies with lower switching losses, leading to increased system efficiency.
- **Multi-Output Design**: Allowing for several LED strings with unique current regulation can meet various illumination needs, especially in automotive or architectural environments.
- **Miniaturization:** Developments in high-frequency switching technology may result in a smaller transformer and circuit, which would make the driver more portable and appropriate for spaces-constrained applications.

- Improved thermal management and protective features, including over-voltage and over-current protections, can improve LED driver dependability in difficult working situations.

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