Analysis and Design of a Single-Stage Isolated AC–DC LED Driver with a Voltage Doubler Rectifier

Introduction:

Light-emitting diodes (LEDs) have many outstanding advantages such as energy-saving, nonpollution, and long lifetime when compared with traditional lighting sources. Therefore, LEDs have become a research focus in recent years, and have been widely used in street lighting, tunnel lighting, automotive lighting, LCD backlight, etc. In these applications above, an ac–dc LED driver is always needed to drive LEDs efficiently.

First, the driver should have power factor correction (PFC) ability to meet the regulations, energy-star, etc. Second, electrical isolation is needed to satisfy the safety requirements. Finally, constant output current is necessary because of the physical characteristics of LEDs. Commonly, a two-stage LED driver is adopted, which contains a PFC stage and an isolated dc–dc stage.

Existing system:

Boost converter, Sepic converter, and buck–boost converter are most frequently used as the PFC unit of the single-stage drivers. They operate in discontinuous conduction mode (DCM) to achieve high PF internally on the condition that the duty ratio $D$ of the power switch keeps constant in half line cycle. The boost-type PFC unit is quite simple and features high efficiency; however, the output voltage of it must be higher than the peak value of the input voltage at least, which
leads to high voltage stress of the switch; Moreover, higher PF means higher output voltage and higher voltage stress.

The sepic type PFC unit can reduce the voltage stress imposed on both the energy-storage capacitor and the switch due to its step up/down capability. However, it contains two inductors and many other components, which may lead to higher cost and lower reliability than the boost-type PFC unit.

**Dis-advantages:**
- Higher cost
- Lower reliability

**Proposed system:**

Single-stage isolated high PF LED driver with leakage inductor energy recycling is proposed. Which integrates a buck–boost converter with a flyback converter by sharing the power switch $Sw$. The buck–boost converter operating in DCM can achieve high PF internally. The voltage spike and ringing on the switch are alleviated due to the leakage inductor energy is recycled via a unidirectional diode, so the switching loss can be reduced and conversion efficiency can be improved.

However, the flyback converter transfers energy from the primary side to the secondary side only when the switch is turned OFF. Low magnetic core utilization results in large volume of the transformer and limits its use to low power applications. A voltage doubler rectifier is included in the secondary side of the transformer, thus, the energy is transferred from the primary side to the secondary side whenever the switch is turned ON or turned OFF. The magnetic core utilization of transformer is improved and may be adopted in higher power applications. Furthermore, the voltage stress of the...
secondary diodes can be reduced remarkably to lower the conducting loss.

**Advantages:**
- Greatly reduces the volume of the isolated transformer as well as the voltage stress.
- High PF can be achieved.

**Applications:**
- Power factor correction applications.
- LED applications.

**Block Diagram:**