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Research Paper

LED DRIVER CIRCUIT

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This paper deals with LED driver circuit is an electrical circuit, which can improve the efficiency and power factor of LED, which can be extend up to 100 watts. This circuit utilizes the Energy-Efficiency, accurate current controller switcher in a primary-side regulated flyback power-supply configuration.

Keywords: Efficiency, Power factor, Current controller, flyback

INTRODUCTION

A LED driver is an electrical device that regulates the power to an LED or string(s) of LEDs. This makes a driver different from conventional power supplies is that an LED driver responds to the varying necessaries of the LED, by supplying a constant power to the LED as its electrical properties change with temperature.

An LED driver as the changing temperature and Cruise Control of the LED are the hills and valleys it is ‘driving’ over. The power level (or ‘Speed’) of the LED is maintained constant by the driver as the electrical properties change (amount of ‘gas’ or power needed) throughout the temperature increases and decreases (or ‘hills and valleys’) at the LED. Without the proper driver, the LED may become too hot and become unstable (out of control), causing poor performance (engine problems) or complete failure.

Circuit Description

This circuit utilizes the Energy†Efficient, Accurate Current Controller (CC) Switcher in a primary†side regulated flyback power†supply configuration. The SWITCHER device (U1) incorporates a power switching device, an oscillator, startup and protection functions and CC control engine all as part of one IC. It has an integrated 700 V MOSFET that allows sufficient voltage margin for universal input AC applications.

The power supply delivers full output current during the maximum forward voltage drop of the LED. The SWITCHER’s IC package provides extended creep age distance between high and low voltage pins (both at the

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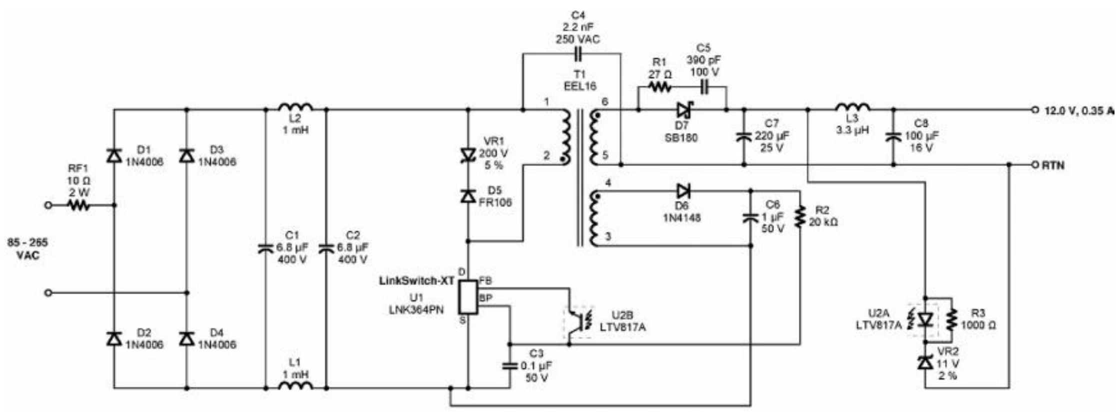
Figure 1: Circuit Diagram



package and the PCB), which is required in high humidity conditions to prevent arcing and to further improve reliability. The EE16 transformer bobbin provides extended creep age to meet safety spacing requirements.

Switcher Operation

The SWITCHER monolithically integrates a 700 V power MOSFET switch with an ON/OFF control function (for transformer core and CC functions). The Constant Voltage (CV) regulation uses the unique ON/OFF control scheme which provides tight regulation over a wide temperature range. Beyond the maximum power point, the switching frequency is reduced to provide constant†current operation.

This makes the SWITCHER ideal for driving LEDs, which require a constant current for consistent light output level. In addition, this integrated current and voltage regulator compensates for not only transformer inductance tolerances and internal device parameters, but input voltage variations as well.

Input Filter

Input Diodes rectify the AC input power. The rectified DC is filtered by the bulk storage capacitors. Inductors, with capacitors, form pi (π) filters which attenuate conducted differential mode EMI noise. This configuration, along with transformer E†shield technology, allows this design to meet EMI standard EN55015 class B with 10 dB of margin level and without using the isolation capacitor. Resistors damp out excessive ringing and improve EMI immunity. Fusible, flameproof resistor provides differential EMI filtering, limits inrush current when AC is applied and it act as a fuse.

Switcher Primary

The SWITCHER device incorporates a power switching device, an oscillator, startup, protection functions, and a CC/CV control engine, all in one IC. The 700 V MOSFET allows for sufficient voltage margin in universal input AC applications. The device is self powered completely from the bypass pin and decoupling capacitor. The rectified and filtered input voltage is applied to one side of the primary winding. The other side of primary winding is driven by the integrated MOSFET in Switcher. AnRCD†R clamp consisting of Diode, Resistors and Capacitor limits any drain†voltage spikes caused by leakage inductance.

Output Rectification

The transformer's secondary is rectified by a Scotty†barrier diode (chosen for higher efficiency), and filtered by an Electrolytic capacitor. In this application Electrolytic capacitor has a low ESR, by design, which enables the circuit to meet the required output voltage ripple requirement without using an LC-post filter.

Output Regulation

The SWITCHER regulates output using ON/ OFF control for Constant Current (CC) and frequency control and CV regulation. Feedback resistors have 1% tolerance values to accurately center both the nominal output voltage and the current in CC operation. The CV feature provides output Over-Voltage Protection (OVP) in case any LEDs fail open-circuit. Upon detecting the maximum power point, the controller goes into CC mode.

While the SWITCHER operates in the CV region, it regulates the output voltage by ON/ OFF control. The output voltage level is maintained by adjusting the ratio of enabled cycles to the disabled cycles. The efficiency of the converter is optimized over the entire load range. When the SWITCHER enters a state where no switching cycles are skipped (concurrent with the maximum power point) the controller within the SWITCHER transitions into CC mode. A further increase in the demand for load current causes the output voltage to drop. This drop at the output voltage is reflected on the FB pin voltage. In response to this voltage reduction at the Feedback pin, the switching frequency is reduced to achieve constant output current.

Driving of LEDs with Constant Current

When we apply the constant current to the white LEDs, the illumination of the white LEDs will be much powerful than the other lamb's illumination. There are two reasons to drive them with constant current:

- To avoid violating the Absolute Maximum Current Rating and compromising the reliability.
- To obtain matched luminous intensity and to obtain predictable chromaticity from each LED.

This above application describes the characteristics of a range of typical LEDs and circuits which achieve the necessary constant-current drive.

FLYBACK CONVERTER

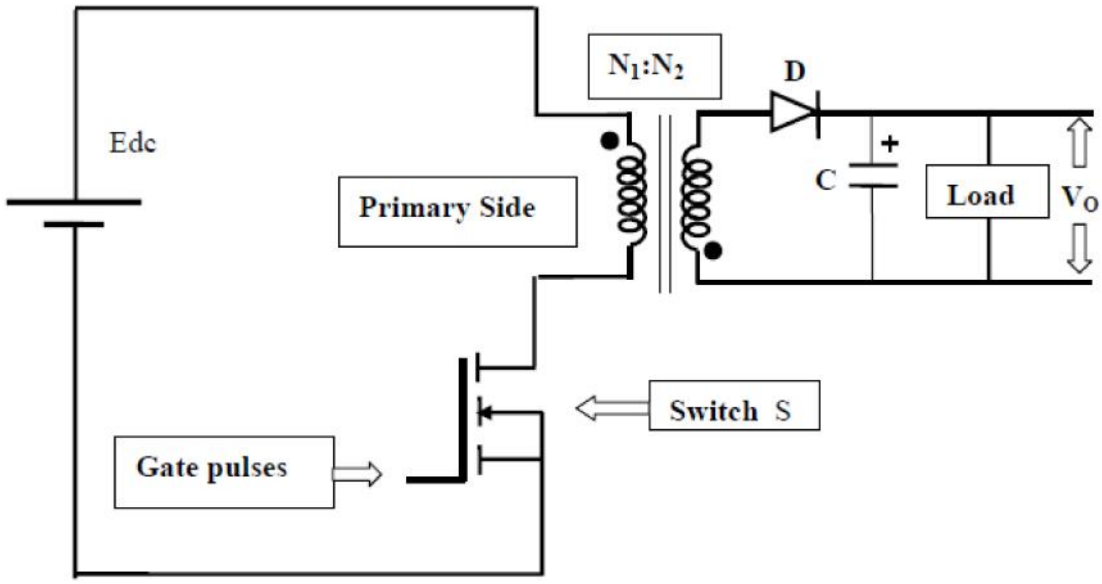
Introduction

The flyback converter is used in both AC/DC and DC/DC conversion with galvanic isolation between the input and outputs. More specifically the flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios levels are multiplied with an advantage of isolation. When considering an example a plasma lamp or a voltage multiplier the rectifying diode of the buck-boost converter is left out and the device is called a flyback transformer.

Operation

Fly-back converter is the most commonly used SMPS circuit for low output power applications where the output voltage needs to be isolated

Figure 2: Operation of Flyback Converter with Two Configurations



from the input main supply. The output power level of the fly-back type SMPS circuits may vary from few watts to less than 100 watts. The overall topology of this converter is considerably simpler than other SMPS circuits. Input of the circuit is generally unregulated dc voltage obtained by rectifying the utility ac voltage followed by a capacitor filter.

The circuit is capable of offering a single or multiple isolated output voltages and can operate over wide range of input voltage variation. Inconsideration of the energy-efficiency, fly-back power supplies are inferior to many other SMPS circuits but its simple topology and low cost makes it popular in low output power range.

The commonly used fly-back converter requires a single controllable switch like, MOSFET and the other switches uses switching frequency ranges to 100 kHz. A two-switch topology exists that offers better energy efficiency and less voltage stress across the switches but costs more and the circuit complexity also increases.

Basic Topology of Fly-Back Converter

Input to the circuit may be unregulated dc voltage derived from the utility ac supply after rectification and filtering. The ripple in dc voltage waveform level is generally of low frequency and the overall ripple voltage waveform repeats at twice the ac mains frequency. Since the SMPS circuits are operated at much higher frequency (in the range of 100 kHz) the input may be considered to have a constant magnitude during any high frequency cycle. A fast switching device ('S'), like a MOSFET, is used with fast dynamic control over switch duty ratio (ratio of ON time to switching time-period) to maintain the desired output voltage.

The transformer is used for the purpose of voltage isolation as well as for better matching between input and output voltage and current levels at required range. Primary winding and secondary winding of the transformer are wound to have good coupling so that they are linked by nearly same magnetic flux.. In a normal transformer under load condition primary winding and secondary winding conduct simultaneously such that the ampere turns of primary winding is nearly balanced by the opposing ampere-turns of the secondary winding (the small difference in ampere-turns is required to establish flux in the non-ideal core).

Since primary and secondary windings of the fly-back transformer don't conduct simultaneously they are more like two magnetically coupled inductors and it may be more appropriate to call the fly-back transformer as inductor-transformer. Similarly the magnetic circuit design of a fly-back transformer is done like that for an inductor.

The output section of fly-back transformer, which consists of a voltage filtering and voltage rectification, is considerably simpler than in most other switched mode power supply circuits. The secondary winding voltage is rectified and filtered using just a diode and a capacitor. The Voltage level experienced across this filter capacitor is the SMPS output voltage.

A more practical circuit has provisions for output current and voltage feedback and a controller in order for modulating the duty ratio of the switch. It's quite usual to have multiple secondary windings for generating multiple isolated voltages levels. One of the secondary outputs may be dedicated only for estimating the load voltage and for supplying the controlled power to the circuit. Further, a snubber circuit will be required in order to dissipate the stored energy from the leakage inductance of the primary winding of the transformer when the switch 'S' is turned off.

Thus the operation of the circuit is explained without considering the winding leakage inductances. The ON state voltage drops of diodes and switches are neglected. The windings of the transformer, the transformer core and capacitors, etc., are assumed to be loss-less. The input dc supply is also assumed as a ripple-free.

Continuous versus Discontinuous Flux Mode of Operation

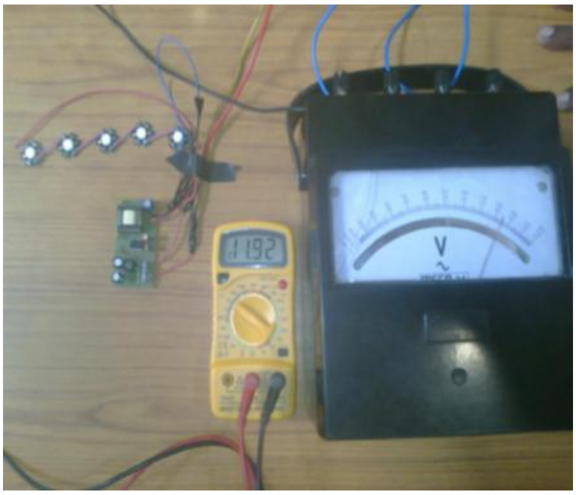
A practical fly-back type SMPS circuit will have a closed loop control circuit for output voltage regulation. The controller is used to modulate the duty ratio of the switch so as to maintain the output voltage within a small tolerable ripple voltage band around the desired output value.

If the load is very light, very small amount of energy needs to be input to the circuit in each switching cycle. This is achieved easily by maintaining the ON duration of the switch low, resulting in low duty ratio (¢). Within this small ON time only a small amount of current builds up in the primary winding. The off duration of the switch, which can be given as (1-¢) fraction of the switching time period, which is relatively large.

Mode-2 duration of the circuit operation is also small as the magnetic field energy is quickly discharged into the output capacitor. Thus, during the light load experience, the circuit will be in mode-3 condition for significant duration. As the load increases the mode-3 duration, during which there is zero winding currents and zero flux through the core reduces and the circuit is driven drastically towards the continuous flux mode. The circuit operation changes from discontinuous to continuous flux mode if the output power from the circuit increases beyond the certain value. Similarly if the applied input voltage decreases from the level, keeping the load power and switching frequency constant, the circuit tends to go in continuous flux mode of operation.

Figure 3: Prototype Model of LED Drive Circuit

(a)



(b)

To achieve better control over the output voltage level, discontinuous flux operating mode is preferred as a better choice. However, for the given transformer consideration and switch ratings, etc., more output power can be transferred effectively during the continuous flux mode of operation. A general design thumb rule is to design the circuit for operation at just-continuous flux mode of operation at the minimum expected input voltage range and at the maximum output power level.

CONCLUSION

10 W LED driver circuit designed and developed. The performance of LED circuit has been verified for variable voltage condition. Under all voltage condition the power factor is unity. 5 W LED light output light intensity much higher than the CFL and incandescent lamp. This shows that going forward LED lights will replace all other electrical light source which will be more efficient.

REFERENCES

1. Billings and Keith (1999), “Switch Mode Power Supply Handbook”, McGraw-Hill Publications.
2. Col W T McLymon (1988), *Transformer and Inductor Design Handbook*, 2nd Edition, Marcel Dekker Inc., New York, ISBN:0-8247-7828-6.
3. Dixon Lloyd H (2001), “Magnetics Design Handbook, Section 5, Inductor and Flyback Transformer Design”, Texas Instruments.
4. Fu Wong and Lu J W (1996), “Applications of High Magnetic

Components for Switching Resonant Mode Power Supply", Proc. IEEE ICIT.

5. Keith and Billings (2003), "Designing Fly Back Transformer for Discontinuous Mode", DKB Power Inc., Ontario, Canada.

6. Maksimovic D and Erickson R W (1997), *Fundamentals of Power Electronics*, 2nd Edition, Kluwer Academic Publishers.

7. Mohan Tore M and Robbins William P (2003), "Power Electronics Hand Book", John Wiley & Sons, Inc.