Deepak Agrawal, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 12, Issue 4, (Series-II) April 2022, pp. 01-04

RESEARCH ARTICLE OPEN ACCESS

DC-DC converter Topologies for LED Driver: A Review

Deepak Agrawal
Faculty of Engg. and Tech., Madhyanchal Professional University, Bhopal (M.P.), India

Bhagwat Kakde
Faculty of Engg. and Tech., Madhyanchal Professional University, Bhopal (M.P.), India

Rajneesh Karn
Faculty of Engg. and Tech., Madhyanchal Professional University, Bhopal (M.P.), India

Abstract
This paper explicates different types of Light Emitting Diode (LED) driver in regards to their functions, efficiency, limitations and key features. A comparative study has been done, in which a conventional LED driver is accompany by different techniques and components, to provide efficient results and power factor. Additionally, this paper explicates how various losses such as driving loss, component loss and other losses can be strongly reduced by gradually increasing the driving time period. Part of this paper also covers the efficiency, input voltage, number of switches used and efficiency obtained when any conventional driver subjecting to various methods and topologies. Also, the input voltage level varies from 1.2V to a maximum of 310V and up to 98% efficiency has been released.
Keywords— Power Electronics Converters; LED; LED Drivers.

Date of Submission: 04-04-2022 Date of Acceptance: 19-04-2022

I. INTRODUCTION

The LED lights are the most vital artificial source of illumination due to its cost-effectiveness, efficiency and many other benefits as compare to High Pressure Sodium (HPS) [1]. Hence LEDs have developed an extensive market and HPS is being replaced by LEDs. As the demand of LEDs is growing day by day so it has given tremendous growth to the industries of LED drivers The LED drivers circuits are required to control the functioning of LEDs [2], these LED drivers not only efficiently convert alternating current (AC) to direct current (DC) but also pass up thermal runaway, a condition in which a decrease in forward voltage and a rise in temperature causes the LEDs to themselves [3].

In practical situations, the demand of LEDs is increasing regularly but the losses in driver sometimes decreases their lifespan, so it becomes more important to increase efficiency, performance and controllability of these drivers [4]. In practical terms, the demand for LEDs is rising in the market, but driver loss sometimes shortens their lifespan, so it turns out to be more important to enhance their life span efficiency, performance and controllability of these LED drivers. This paper is a concise study of the various methods that can be realized with modern LEDs and some of these methods conversed in this paper has its own benefits which is helpful in solving the key difficulties of LED drivers.

II. LITERATURE REVIEW

A. LED Driver for Pixel Light

P. Horsky, J. Plojhar and J. Daniel [5], this paper gives LED driver topology for Automotive lighting or Pixel lighting system. A buck converter with current sensing on high side of switch and average current regulation control scheme is shown in this paper. The brightness of LED can be controlled from 0% - 100%. The efficiency of this driver is 95.7%. The circuit diagram of dc-dc convertor for driving LED string is shown in Figure 1.

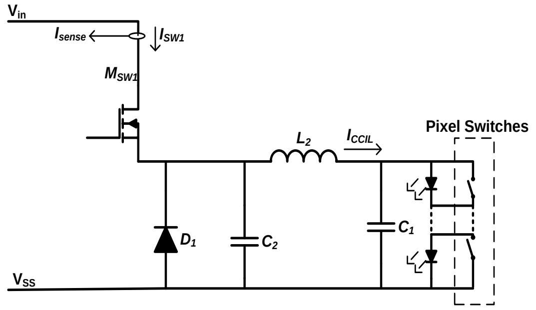

Fig. 1 Circuit of dc-dc converter for driving LED string [5]

B. Interleaved Integrated Buck Flyback Converter

G. Z. Abdelmessih, J. M. Alonso and W. Tsai [6], have modified available conventional integrated buck flyback converter (IBFC) topology for LED drivers and presented new interleaved integrated buck flyback converter (IIBFC). The IIBFC eliminates problem occurring in convention IBFC i.e. doesn't operate at rated power when dimming is applied, more components, high cost etc. The main concept of this topology is addition of third winding which is known as interleave winding for improving power factor (0.997). The turn ratio of primary winding and interleave winding is fixed at 1:1. This is two stage driver consisting of power factor correction as first stage which is buck converter and dc/dc converter as second stage which is flyback converter. The drawbacks of topology are reduced lifespan, low efficiency and low reliability. The circuit diagram of IIBFC topology is Figure 2.

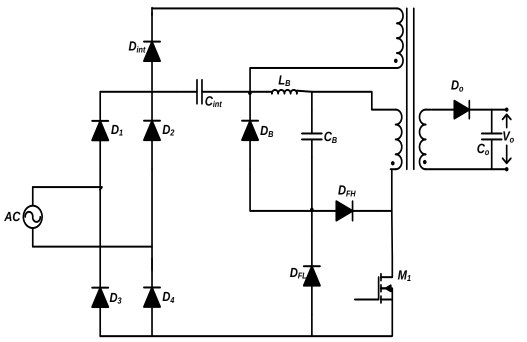

Fig. 2. Circuit of Interleave Integrated Buck Flyback LED driver [6]

C. 2-channel interleaved buck LED driver with current-sharing capacitor

D. Do, H. Cha, B. L. Nguyen and H. Kim [7], has presented this topology which has an interleaved buck converter controlled by phase shift PWM. An interleaved buck converter in voltage regulator mode has a feature of balancing two inductor currents by charging and discharging the series capacitor so that current can be balanced automatically with the help of one control circuit in multi string LED applications. The efficiency achieved in this topology is between 96.1 – 96.9%. The circuit diagram of modified buck LED driver is shown in Figure 3

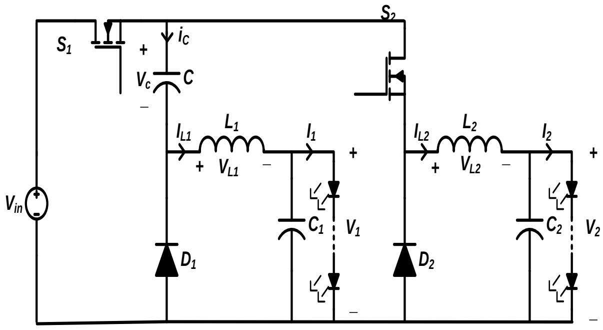

Fig. 3 Circuit of two - channel Interleave Buck LED driver [7]

D. Battery operated soft switching buck boost LED driver

F. Pouladi, H. Farzanehfard and E. Adib [8], presented a LED driver topology which is used where forward voltage capacity of LED string varies because of variation in the temperature i.e. mainly used for battery operated LED applications. The soft switching techniques i.e. ZCS & ZVS are used to drive switches (ZCS for main switch and ZVS for auxiliary switch) and converter used for the topology is buck-boost converter. The topology employs two switches, one is auxiliary switch and another is main switch. If both switches operate then converter works in boost mode and if auxiliary switch is turned off and only main switch conducts then converter works in buck mode. Due to operation of converter in both modes, it provides LEDs the versatility to operate with different colors and because of use of only one magnetizing component system volume has also been reduced. The circuit diagram of resonant buck-boost LED driver is shown in Figure 4.

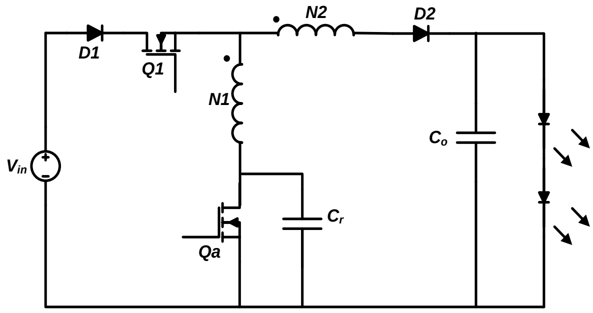

Fig. 4. Circuit of resonant Buck-boost LED driver [8]

E. Current-Mode-Controller Design of Buck LED Driver

Marn-Go Kim [9], suggested a current mode control (CMC)-based LED driver featuring linearized buck converter with slope compensation and a linearized proportional integral compensation for error amplifier is shown. This topology has output current regulator to achieve constant current at the output. It uses discrete time approach instead of continuous time approach for modeling of system.

The close loop control is also analyzed and designed with the help of root locus. The circuit diagram of constant frequency current mode controlled LED driver is shown in Figure 5.

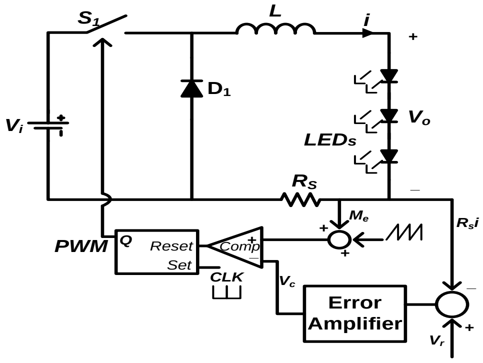

Fig. 5. Circuit of constant frequency current mode controlled buck LED driver [9]

F. Flexible Mode ECF LED Driver

J. Zeng, F. Liu, J. Liu and K. W. E. Cheng [10], has presented a novel LED driver which has two parts: Flexible mode boost PFC converter and half-bridge DC-DC converter is suggested. The flexible mode boost PFC converter is a rectifier which has input filter, to filter input current ripple and also correct the power factor as it works under discontinuous mode of conduction (DCM) and converts AC into DC. This DC voltage is fed to half-bridge DC-DC converter. The output current is balanced by the capacitor charge balance. The major advantage of this topology is that it can work over wide range of input voltage. The circuit diagram of flexible LED driver is shown in Figure 6.

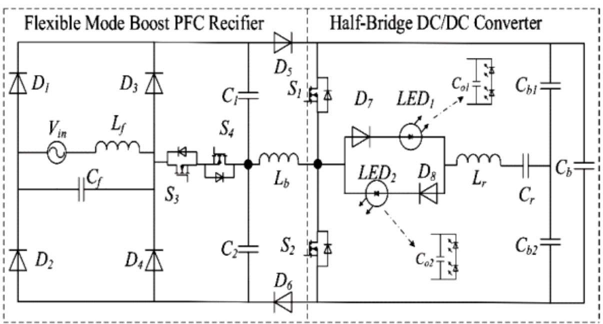

Fig. 6 Circuit of flexible mode LED driver [10]

III. COMPARATIVE ANALYSIS OF LED DRIVERS

In this section different topologies are compared on the basis of parameters such as efficiency, input voltage component required and the comparison has been presented in the table I.

TABLE I

COMPARATIVE ANALYSIS OF LED DRIVERS

Ref	[5]	[6]	[7]	[8]	[9]	[10]
Efficiency	95.7%	80%	96.9%	92.9%	-	92.85%
Input	6-65V	110V	400V	12V	30-70V	110-220V
Output	-	-	100V	32	16.25V	60V
Number of switches	1	1	2	2	1	4
Converter type	Buck	Buck	Buck	Buck-boost	Buck	Boost

IV. CONCLUSION

This paper studies various types of implementation on buck, boost and buck boost convertor which showed different results and every implementation has its own advantage and limitation and can be used with different environments. This paper mainly focuses on studying the comparative analysis of LED drivers in different situation. The methods discussed in this paper are reliable, cost effective and can be implemented with modern LEDs for making it more efficient as efficiency varied from 80-96.9% in the above discussed methods.

REFERENCES

[1]. Castro, A. Vazquez, D. G. Aller, M. Arias, D. G. Lamar and J. Sebastián, "On Supplying LEDs From Very Low DC Voltages With High-Frequency AC-LED Drivers," in IEEE Transactions on Power Electronics, vol. 34, no. 6, pp. 5711-5719, June 2019, doi: 10.1109/TPEL.2018.2869795.

[2]. S. Lee, H. Choe and J. Yun, "Performance Improvement of a Boost LED Driver With High Voltage Gain for Edge-Lit LED Backlights," in IEEE Transactions on Circuits and Systems II: Express Briefs, vol. 65, no. 4, pp. 481-485, April 2018, doi: 10.1109/TCSII.2017.2716442.

[3]. D. O. Bamgboje, W. Harmon, M. Tahan and T. Hu, "Low Cost High Performance LED Driver Based on a Self-Oscillating Boost Converter," in IEEE Transactions on Power Electronics, vol. 34, no. 10, pp. 10021-10034, Oct. 2019, doi: 10.1109/TPEL.2018.2890627.

[4]. D. Gacio, J. M. Alonso, J. Garcia, D. Garcia-Llera and J. Cardesin, "Optimization of a Front-End DCM Buck PFP for an HPF Integrated Single-Stage LED Driver," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 3, pp. 666-678, Sept. 2015, doi: 10.1109/JESTPE.2015.2424221.

[5]. P. Horsky, J. Plojhar and J. Daniel, "Adaptive Peak Average Current Control LED Driver for Automotive Lighting," in IEEE Solid-State Circuits Letters, vol. 2, no. 9, pp. 199-202, Sept. 2019.

[6]. Z. Abdelmessih, J. M. Alonso and W. Tsai, “Analysis and Experimentation on a New High Power Factor Off-Line LED Driver Based on Interleaved Integrated Buck Flyback Converter,” in IEEE Transactions on Industry Applications, vol. 55, no. 4, pp. 4359-4369, July-Aug. 2019.

[7]. D. Do, H. Cha, B. L. Nguyen and H. Kim, "Two-Channel Interleaved Buck LED Driver Using Current-Balancing Capacitor," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 6, no. 3, pp. 1306-1313, Sept. 2018.

[8]. F. Pouladi, H. Farzanehfard and E. Adib, "Battery Operated Soft Switching Resonant Buck–Boost LED Driver with Single Magnetic Element," in IEEE Transactions on Power Electronics, vol. 34, no. 3, pp. 2704-2711, March 2019.

[9]. M. Kim, "High-Performance Current-Mode-Controller Design of Buck LED Driver with Slope Compensation," in IEEE Transactions on Power Electronics, vol. 33, no. 1, pp. 641-649, Jan. 2018.

[10]. J. Zeng, F. Liu, J. Liu and K. W. E. Cheng, "A Flexible Mode Electrolytic Capacitor-Free LED Driver with High Efficiency Over a Wide Range of Input Voltage," in IEEE Transactions on Power Electronics, vol. 35, no. 8, pp. 8490-8500, 2020.

Deepak Agrawal, et. al. “DC-DC converter Topologies for LED Driver: A Review.” *International Journal of Engineering Research and Applications (IJERA)*, vol.12 (04), 2022, pp 01-04.