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Electrolytic Capacitor less Led Driver Based On Series Resonant Converter with Power Factor Control

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ABSTRACT
This paper proposes electrolytic capacitor (EC) less power factor correction (PFC) light emitting diode (LED) driver with reduced ripple in current. Generally PFC LED drivers need huge electrolytic capacitors to reduce output current ripple. The life-span of LED driver is significantly reduced due to short life-span of electrolytic capacitors, and hence demands for electrolytic capacitors less LED drivers. The proposed method is to attenuate the low frequency ripples delivered from the Power Factor Correction (PFC) to LEDs; therefore, the capacitance is reduced for energy storage of off-line LED drivers. On adoption of the Switching Controlled Capacitor (SCC), the constant frequency control (CFC) is achieved by the regulations of the equivalent capacitance. Half-bridge switches are shared by the bridgeless PFC as well as by resonant unit, therefore, single-stage LED drive is realized with high efficiency. In addition, SCC is simultaneously shared for the upper and lower half-bridge which reduces the cost and improve the power density of driver. Detailed examination of Operating principle, design considerations and performance comparisons are done. Finally, superior performances of proposed LED driver are verified by simulation and experimentally with 2-channel LEDs.
Keywords – CFC-Constant frequency control, EC- electrolytic capacitor, LED-Light emitting diode, PFC-Power factor correction, SCC- Switched controlled capacitor.

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I. INTRODUCTION

High brightness LED is next generation of green lighting. Its outstanding advantages are due to long life time, environment friendly, high illumination efficiency [1, 2]. Bridgeless converter integrates the operation of bridgeless power factor correction booster rectifier and asymmetrical pulse width modulation half bridge dc-dc converter [3]. In a single-stage AC/DC converter based on the interleaved sepic circuit and flyback converter, the interleaved sepic circuit and flyback converter share a switching device, the costs of the system can be reduced, the efficiency, reliability can be improved and ripple current get reduced[4]. Even though light-emitting diodes (LEDs) may have a very long life, poorly designed LED lighting systems can experience a short life [5].With feed forward control, the output current ripple can be reduced without electrolytic capacitor, and the lifetime of the driver will be increased [6]. The single stage PFC circuit with small energy storage capacitance can still achieve good output voltage regulation while preserving desired input power factor [7]. The traditional topology of off-line drive is composed of PFC unit, DC/DC converter and multiple LED strings [8, 9]. Most of the converters realize component reutilization such that those topologies contain bridge rectifier, in which front end diodes introduce the higher conduction loss [10, 11, 12]. The lifetime of an ac-dc LED driver can be increased by eliminating the electrolytic capacitor. Unfortunately, it results in pulsation with twice the line frequency in the driving current. Injection of the third and fifth harmonics into the input current can reduce the peak-to-average ratio of the driving current, which is beneficial for reliable operation of the LEDs[13], bidirectional converter can also be used to absorb the second harmonic component in the output current of the PFC converter, thus producing a pure dc output to driver[14], also the energy storage capacitor can be moved to the rectifier side with a three-winding transformer used to provide isolation such that input power factor correction as well as to store and provide the required energy to the output[16]. LLC converters face challenges in high-current applications, where the high conduction loss limits the maximum load capacity and reduces efficiency. Interleaving technique can be used to solve this problem, but the component tolerances of the resonant tanks will cause severe load sharing problem [18]. In high frequency AC-LED driver, front-stage is a boost power-factor correction (PFC) circuit and the rear-stage is a half bridge series resonant inverter, the design uses the digital dimming control to reduce LED chromaticity shift, and connect the LEDs as a full-bridge rectifier to simplify the current sensing circuit[19]. In [15] paper two non isolated single-stage high power factor converters requiring low dc-link capacitance is used where both converters result from the integration of the power factor correction and the LEDs driver stages, and require a relatively low dc-link capacitance value. By employing a series resonant DC-DC converter the low-frequency ripple transmitted from the PFC stage to the LEDs can be minimized [17]. In order to design a high-efficiency driver for supplying multiple light-emitting diode (LED) strings in parallel, a novel single-stage bridgeless, soft-switched integrated AC-DC converter is used, the proposed converter can be derived by integrating the totem-pole bridgeless boost power factor correction (PFC) circuit and half-bridge LLC resonant converter[20]. Novel passive-type LED driver can regulate LED power statically for the source voltage variation, which is based on passive type LED driver, which does not use pulse-width-modulation (PWM) technique [21]. A feed-forward control for the single-stage PFC converters can be proposed to improve the dynamic response of the control loop so that the flicker can be eliminated [22]. The compact LED module significantly improves the reliability, reduces system cost, and cuts down the physical size of the module by more than 70 percent [23]. The dimming feature is accomplished by means of current amplitude modulation (AM) or double pulse-width modulation [24]. The potential of LED for indoor applications and demonstrates a white LED lamp module to replace the compact fluorescent lamp (CFL) and to reduce the energy consumption. Furthermore, a prototype of LED lamp module was fabricated to demonstrate the feasibility of such a lighting device, where the LED lamp module is compared to (CFL) [25].

II. EXISTING SYSTEM

The LED driver proposed in the existing system allows the power supply voltage to be in a wide range below the LED strings' channel voltages, making it more applicable to portable devices powered by batteries. Another difference is that a low frequency time-sharing among the power channel switches is implemented in this system, which allows full range duty ratio for the boost converter's main switch when each channel is charged. This in turn gives full control to the boost converter, which is essential to a wide range of power supply voltage, robust stability and good transient performances. These features of the proposed LED driver is enabled by a unique combination of synchronous integrators, variable dimming frequency and a new time multiplexing scheme.

2.1. DRAWBACKS

- Needs bulky electrolytic capacitors in the output side.
- Poor power factor
- Moderate efficiency at High cost
- High electromagnetic interference

III. PROPOSED SYSTEM

The proposed circuit of LED driver is derived by integrating two units, front-end bridgeless PFC unit and the back-end half-bridge resonant unit (Power Control) respectively. SCC maintains constant operating frequency for the power switches. Reason for using constant frequency control is to increase stability and reduce electromagnetic interference. The single-stage LED driver is obtained by the sharing of the half-bridge module. The upper and lower symmetric outputs will increase the scalability of the current sharing. Also the dimming unit (SCC, L_r) is shared by upper and lower half-bridge.

The proposed topology consist of L_f and C_f which are input filters, L_b is boost inductor, D_1 and D_2 are boost diodes, Q_1 and Q_2 are power switches, C_{b1} and C_{b2} are dc capacitors, S_1, S_2 , C_e , C_{s1}, C_{s2} forms the SCC unit. In oder to achieve zero voltage switching of power switches, SRC are is designed to be inductive. The boost inductor L_b is operated at discontinuous conduction mode. SCC unit accomplish the dimming control

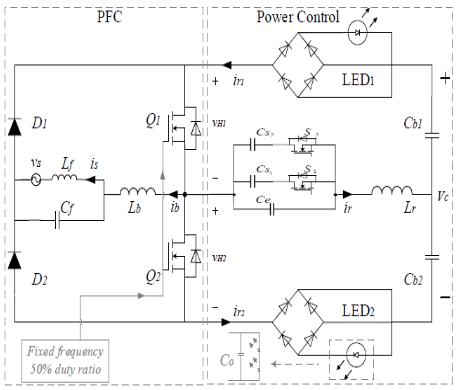

Fig.1 Proposed driver for multiple LED strings (LED driver circuit).

IV. OBJECTIVES

- To design and develop a high efficiency single stage LED driver.
- To reduce the capacitance value required for ripple cancelation.

- To make use of thin film capacitor instead of electrolytic ones in order to improve the life time of the LED driver.
- To maintain unity power factor and reduce the EMI by using constant frequency PWM control method.

V. BRIDGELESS CONVERTERS

Bridgeless PFC topologies are currently gaining increasing interests. Generally, bridgeless PFC converters suffer from the issue of implementation and management, however a bridgeless topology will cut back conductivity losses from rectifying bridges; so, overall system potency may be increased. In addition, a bridgeless topology has the advantage of total harmonic distortion (THD) decreasing from input diode reduction.

VI. REVIEW OF ANALOG AND DIGITAL CONTROL

This briefly introduces the advantages and disadvantages of analog control and digital control. In general, digital control is recognized as being flexible and adaptable to changes in system environment and specifications. Thus, digital controller parameters can be modified easily to address variations in device parameters. Moreover, a digital controller has the ability to implement adaptive control. On the other hand, in analog control, manifold small components must be replaced to change control parameters. However, the time delay caused by the computation of a control algorithm with DSP should be considered in digital controller implementation. In addition, the fewer components are required in digital controller implementation, this causes the cost saving. However, this reduction of the cost may not always apply for low-power applications. Many low-cost digital ICs are currently on the market. The selection of low-cost digital control ICs should be considered to take advantage of digital control in low-power applications.

VII. RESULTS AND ANALYSIS

7.1SIMULATION ANALYSIS

The proposed LED driver is evaluated in Matlab simulation with two output channel of LED in fig.2 and the corresponding output of simulation is shown in fig3. With output voltage of about 120Volt.

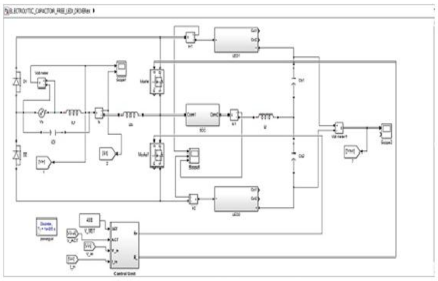

Fig.2 Simulink diagram

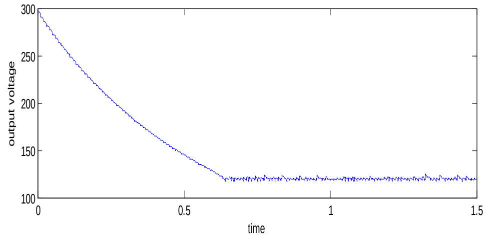

Fig.3 Simulink Ouput Voltage

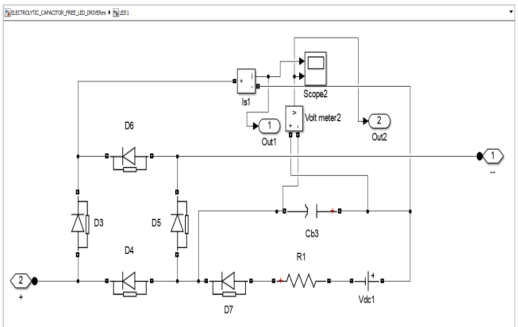

Fig.4 LED circuit

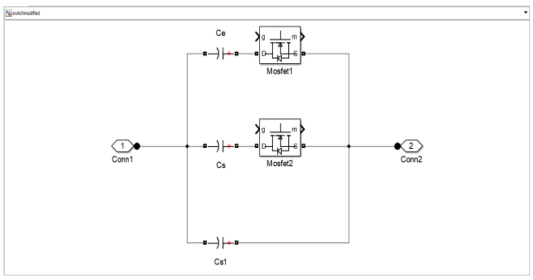

Fig.5 Switched controlled capacitor circuit

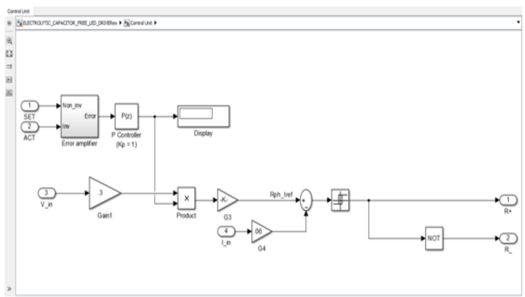

Fig.6 control circuit

7.2 HARDWARE RESULTS

Experimental prototype is demonstrated with output voltage of 120Volt. 12Volt and 20Watt LED is used Control signal from microcontroller dspic30F2010 is transmitted to opto coupler. Both power switches are triggered by half bridge driver IR2110. Output current is detected by current sensor, VMR type sensor is used as current sensor and larger current is selected as input of control unit.

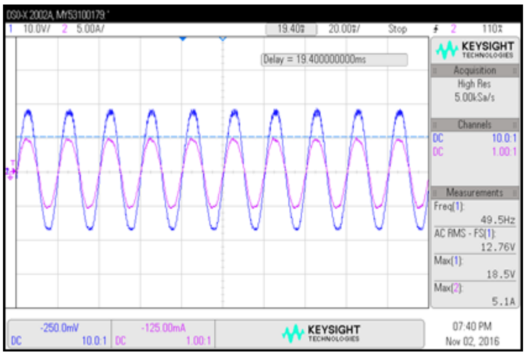

Fig.7 Input AC source voltage & current

The fig.7 shows the hardware results of both input voltage and current. Both are in phase. This is lead to unity power factor operation.

Fig.8 PWM pulse to the converter

The fig.8 shows the PWM pulses to the converter, the first pulse is given to the not gate, and it is fed to the second switch. The PWM pulses are having 20 KHz switching frequency.

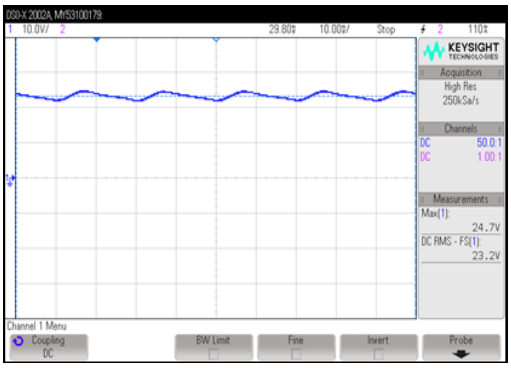

Fig.9 Output voltage of the converter

The fig.9 shows the hardware output voltage of converter. Constant frequency control technique is used to get constant voltage.

VIII. CONCLUSION

In this paper, EC-less LED driver is designed and analyzed in detail. A prototype of EC-less PFC based LED driver with resonant converter integrated is built and practical results are validated with simulation The proposed LED driver is able to absorb the ripple current of twice line frequency and Allow ripple free current to the load without using ECs which simplifies control complexity.

REFERENCES

[1]. H. L Tian, J. F. Liu and J. Zeng, "A bridgeless electrolytic capacitor-free LED driver based on series-resonant converter with constant frequency control," 2017 7th International Conference on Power Electronics Systems and Applications - Smart Mobility, Power Transfer & Security (PESA), Hong Kong, 2017, pp. 1-5.

[2]. Y. Wang, J. M. Alonso and X. Ruan, "A Review of LED Drivers and Related Technologies," in IEEE Transactions on Industrial Electronics, vol. 64, no. 7, pp. 5754-5765, July 2017.

[3]. W. Choi, W. Yu and J. Lai, "A novel bridgeless single-stage half-bridge AC/DC converter," 2010 Twenty-Fifth Annual IEEE Applied Power Electronics Conference and Exposition (APEC), Palm Springs, CA, 2010, pp. 42-46.

[4]. M. R. A. Geo, P. Anandhraj, J. A. Ancy and K. Bharathi, "A novel interleaved single-stage AC/DC converter for two stage LED street light system," 2014 IEEE National Conference on Emerging Trends In New & Renewable Energy Sources And Energy Management (NCET NRES EM), Chennai, 2014, pp. 102-104.

[5]. N. Narendran and Y. Gu, "Life of LED-based white light sources," in Journal of Display Technology, vol. 1, no. 1, pp. 167-171, Sept. 2005.

[6]. Y. Shen et al., "Non-electrolytic capacitor LED driver with feedforward control," 2015 IEEE Energy Conversion Congress and Exposition (ECCE), Montreal, QC, 2015, pp. 3223-3230.

[7]. Zhang Bo, Yang Xu, Xu Ming, Chen Qiaoliang and Wang Zhaoan, "Design of Boost-Flyback Single-Stage PFC converter for LED power supply without electrolytic capacitor for energy-storage," 2009 IEEE 6th International Power Electronics and Motion Control Conference, Wuhan, 2009, pp. 1668-1671.

[8]. M. R. A. Geo, P. Anandhraj, J. A. Ancy and K. Bharathi, "A novel interleaved single-stage AC/DC converter for two stage LED street light system," 2014 IEEE National Conference on Emerging Trends In New & Renewable Energy Sources And Energy Management (NCET NRES EM), Chennai, 2014, pp. 102-104.

[9]. M. Tahan and T. Hu, "Multiple String LED Driver With Flexible and High-Performance PWM Dimming Control," in IEEE Transactions on

Power Electronics, vol. 32, no. 12, pp. 9293-9306, Dec. 2017.

[10]. Y. Wang, J. Huang, W. Wang and D. Xu, "A single-stage single-switch LED driver based on integrated buck-boost circuit and Class E converter," 2015 IEEE Industry Applications Society Annual Meeting, Addison, TX, 2015, pp. 1-5.

[11]. Y. Wang, N. Qi, Y. Guan, C. Cecati and D. Xu, "A Single-Stage LED Driver Based on SEPIC and LLC Circuits," in IEEE Transactions on Industrial Electronics, vol. 64, no. 7, pp. 5766-5776, July 2017.

[12]. 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.

[13]. X. Ruan, B. Wang, K. Yao and S. Wang, "Optimum Injected Current Harmonics to Minimize Peak-to-Average Ratio of LED Current for Electrolytic Capacitor-Less AC–DC Drivers," in IEEE Transactions on Power Electronics, vol. 26, no. 7, pp. 1820-1825, July 2011.

[14]. Y. Yang, X. Ruan, L. Zhang, J. He and Z. Ye, "Feed-Forward Scheme for an Electrolytic Capacitor-Less AC/DC LED Driver to Reduce Output Current Ripple," in IEEE Transactions on Power Electronics, vol. 29, no. 10, pp. 5508-5517, Oct. 2014.

[15]. Z. Palhano da Fonseca, A. J. Perin, E. Agostini Junior and C. Bitencourt Nascimento, "Single-Stage High Power Factor Converters Requiring Low DC-Link Capacitance to Drive Power LEDs," in IEEE Transactions on Industrial Electronics, vol. 64, no. 5, pp. 3557-3567, May 2017.

[16]. J. C. W. Lam and P. K. Jain, "Isolated AC/DC Offline High Power Factor Single-Switch LED Drivers Without Electrolytic Capacitors," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 3, pp. 679-690, Sept. 2015.

[17]. P. S. Almeida, M. A. Dalla Costa, J. M. Alonso and H. A. C. Braga, "Application of series resonant converters to reduce ripple transmission to LED arrays in offline drivers," in Electronics Letters, vol. 49, no. 6, pp. 414-415, 14 March 2013.

[18]. Z. Hu, Y. Qiu, Y. Liu and P. C. Sen, "A Control Strategy and Design Method for Interleaved LLC Converters Operating at Variable Switching Frequency," in IEEE Transactions on Power Electronics, vol. 29, no. 8, pp. 4426-4437, Aug. 2014.

[19]. C. Kuo, T. Liang, K. Chen and J. Chen, "Design and implementation of high frequency AC-LED driver with digital dimming," Proceedings of 2010 IEEE International Symposium on Circuits and Systems, Paris, 2010, pp. 3713-3716.

[20]. H. Ma, J. Lai, C. Zheng and P. Sun, (." A High-Efficiency Quasi-Single-Stage Bridgeless Electrolytic Capacitor Free High Power AC–DC Driver for Supplying Multiple LED Strings in Parallel," in IEEE Transactions on Power Electronics, vol. 31, no. 8, pp. 5825-5836, Aug. 2016.

[21]. E. S. Lee, D. T. Nguyen and C. T. Rim, "A novel passive type LED driver for static LED power regulation by multi-stage switching circuits," 2015 IEEE Applied Power Electronics Conference and Exposition (APEC), Charlotte, NC, 2015, pp. 900-905.

[22]. H. Dong, X. Xie, K. Peng, J. Li and C. Zhao, "Feed-forward dynamic compensation control for single-stage PFC LED driver to eliminate flicker to human eyes during AC input voltage variation," IECON 2014 - 40th Annual Conference of the IEEE Industrial Electronics Society, Dallas, TX, 2014, pp. 1460-1465.

[23]. Guoxi Sun, J. G. Liu, Haibing Zhang, Dongming Wang and Z. F. Fan, "A fully-integrated compact LED module with inductor less and capacitor less LED driver," 2013 10th China International Forum on Solid State Lighting (China SSL), Beijing, 2013, pp. 8-11.

[24]. C. Moo, Y. Chen and W. Yang, "An Efficient Driver for Dimmable LED Lighting," in IEEE Transactions on Power Electronics, vol. 27, no. 11, pp. 4613-4618, Nov. 2012.

[25]. R. Sinnadurai, M. K. A. A. Khan, M. Azri and Vikneswaran, "Development of white LED down light for indoor lighting," 2012 IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (STUDENT), Kuala Lumpur, 2012, pp. 242-247.

[26]. Q. Zheng, W. Lin, Y. Xu, L. Wang and N. Wu, "Research on a novel constant power control strategy for single stage PFC LED driver," 2014 11th China International Forum on Solid State Lighting (SSLCHINA), Guangzhou, 2014, pp. 5-8.

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