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Driver Circuits for Dimming of LED

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Abstract: In this paper the driver circuits are proposed for light emitting- diode (LED) lamps with a dimming feature. The two different drivers used are Flyback converter and Forward Converter in series with the dc-link. In this paper the two driver circuits are compared for the controlled output current and voltage. The dimming is achieved by pulse width modulation technique. The variation is observed with the different values of duty cycles. This paper is a comparison between the two driver circuits.

Keywords: Pulse-width modulation (PWM), Flyback converter, Forward Converter, Light-emitting-diode (LED).

I. INTRODUCTION

The light-emitting diode (LED) is the latest technology characterized with mercury free, high efficiency, low power consumption and long life cycle is expected to be the new generation of lighting sources [1]. With the advantage of low power consumption the use of LED has been increased. The problem is the driver circuit which is used to make the LED to glow according to the required purpose. The design of the driver circuits with high variation in the output power is very important for the efficient use of LED .

To provide sufficient light output, an LED lamp fixture always involves large arrays of individual LEDs stacked in combination of series, parallel or both. LEDs are current-driven devices. A white LED’s luminous intensity and chromaticity are proportional to the forward current. For this reason, a driver circuit is designed essentially to drive LEDs at a required constant current. Conventionally, driving a string of high brightness LEDs at an accurate dc current typically resorts to a linear regulator or a more complicated switching regulator especially when a dimming function is included which leads to high cost.

In this paper the overall efficiency of LED lighting is improved. The LED operating characteristics are shown in Fig. 1(a). Theoretically, only a trivial current is generated on an LED when the forward voltage is lower than its cut-in voltage. The LED driver circuit is shown in figure 1(b) in which a string of LEDs is driven by two sources one for providing the cut-in voltage and the other for regulating the forward current. In such a configuration, the dc voltage source for cutting in LED linear operation supplies the majority of the LED power directly, while only a small amount of power has to be processed for current regulation, leading to high overall efficiency.

II. FLYBACK CONVERTER

During its operation fly-back converter assumes different circuit-configurations. Each of these circuit configurations have been referred here as modes of circuit operation. The complete operation of the power supply circuit is explained with the help of functionally equivalent circuits in these different modes.

Mode-1 of circuit operation

$$V_{pri} = E_{dc}$$

$$V_{sec} = E_{dc} * \frac{N_2}{N_1}$$

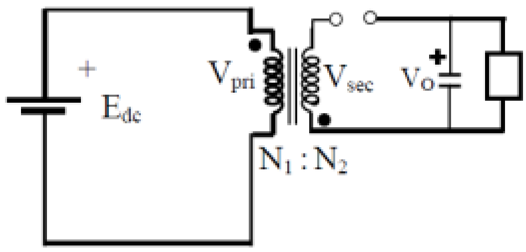

Fig.1: Current path during Mode-1

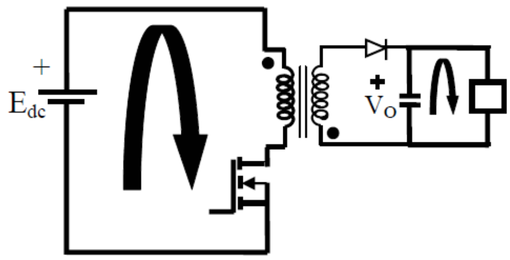

Fig.2: Equivalent circuit in Mode-1

Under Mode-1, the input supply voltage appears across the primary winding inductance and the primary current rises linearly. The following mathematical relation gives an expression for current rise through the primary winding:

$$E_{dc}=L_{pt}*d/dt\ (i_{pt})$$

Mode-2 of circuit operation

It starts when switch ‘S’ is turned off after conducting for some time. The primary winding current path is broken and according to laws of magnetic induction, the voltage polarities across the windings reverse. Reversal of voltage polarities makes the diode in the secondary circuit forward biased. Fig. 3 shows the current path (in bold line) during mode-2 of circuit operation while Fig. 4 shows the functional equivalent of the circuit during this mode.

$$L_{sec}*d/dt(i_{sec})= -V_o$$

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$$V_{pri} = V_o * \frac{N_1}{N_2}$$

$$V_{sec} = V_o$$

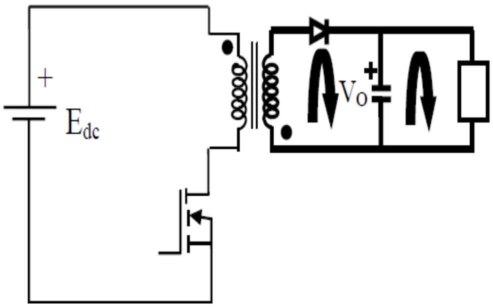

Fig:3 : Current path during Mode-2

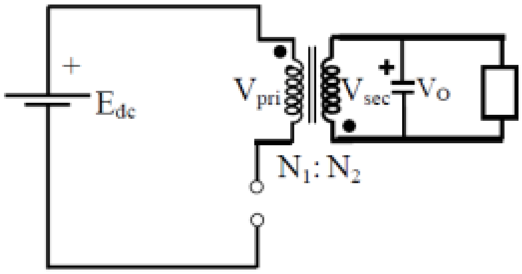

Fig: 4 Equivalent circuit in Mode-2

Mode-3 of circuit operation

Mode-3 ends with turn ON of switch ‘S’ and then the circuit again goes to Mode-1 and the sequence repeats.

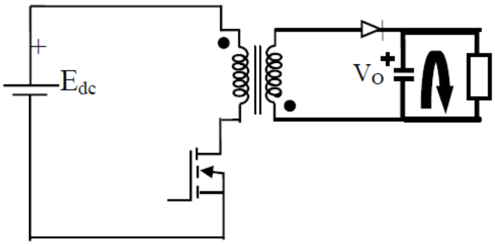

Fig:5 : Current flow path during Mode-3

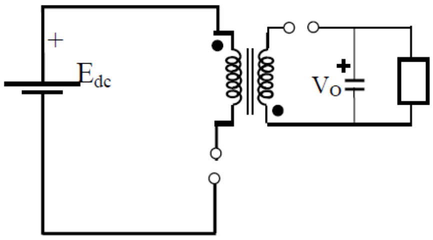

Fig:6 : Equivalent circuit in Mode-3

Fig.5 and Fig 6 respectively show the current path and the equivalent circuit during mode-3 of circuit operation. Fig.7 shows the voltage and current waveforms of the winding over a complete cycle. It may be noted here that even though the two windings of the fly-back transformer don’t conduct simultaneously they are still coupled magnetically (linking the same flux) and hence the induced voltages across the windings are proportional to their number of turns.

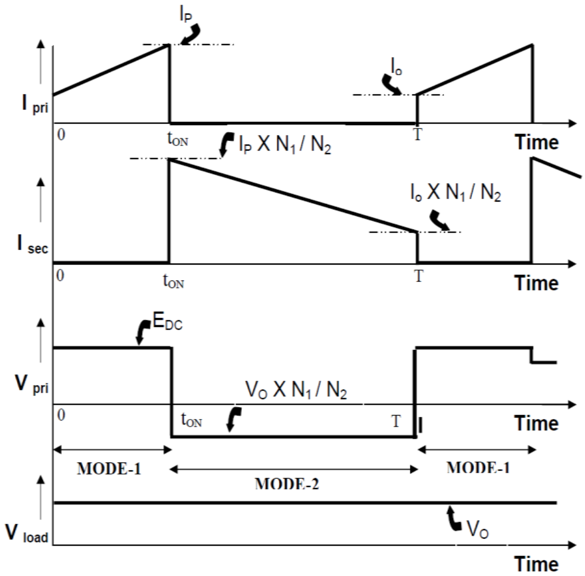

Fig.7: Fly-back circuit waveforms under continuous magnetic flux

III. Forward Converter

Forward converter is another popular switched mode power supply (SMPS) circuit that is used for producing isolated and controlled dc voltage from the unregulated dc input supply.

The basic topology of the forward converter is shown in the figure below. It consists of a fast switching device ‘S’ along with its control circuitry, a transformer with its primary winding connected in series with switch ‘S’ to the input supply and a rectification and filtering circuit for the transformer secondary winding. The load is connected across the rectified output of the transformer-secondary. The transformer used in the forward converter is desired to be an ideal transformer with no leakage fluxes, zero magnetizing current and no losses. The basic operation of the circuit is explained here assuming ideal circuit elements.

Principle of Operation:

For better understanding of the steady-state behavior of the converter, the circuit’s operation is divided in two different modes, mode-1 and mode-2. Mode-1 corresponds to the ‘on’ duration of the switch and mode-2 corresponds to its ‘off’ duration.

Mode-1 of Circuit Operation:

Mode-1 of circuit starts after switch ‘S’ (as shown in Fig.8) is turned ON. This connects the input voltage, E_{dc}, to the primary winding. Both primary and secondary windings start conducting simultaneously with the turning on of the switch. The primary and secondary winding currents and voltages are related to their turns-ratio (N_P / N_S), as in an ideal transformer.

As switch ‘S’ closes, diode D_1 in the secondary circuit gets forward biased and the input voltage, scaled by the transformer turns ratio, gets applied to the secondary circuit. Diode D_2 does not conduct during mode-1, as it remains reverse biased. As can be seen, the output circuit consisting of L-C filter and the load gets a voltage equal to

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$(N_s/N_p)E_{dc}$ during mode-1. Mode-1 can be called as powering mode during which input power is transferred to the load. Mode-2, to be called as freewheeling mode, starts with turning off of the switch 'S'.

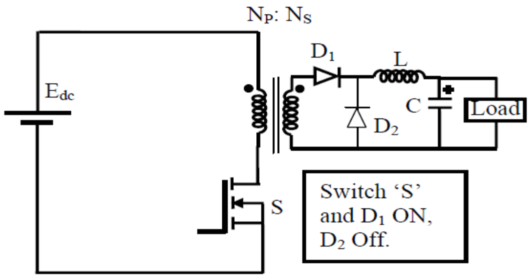

Fig 8: Current path in Mode 1

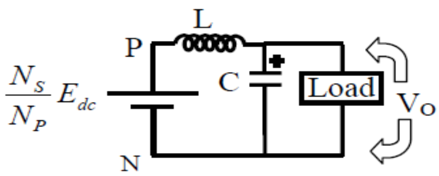

Fig 9: Equivalent circuit in Mode 1

Mode-2 of Circuit Operation :

As soon as switch 'S' is turned off, the primary and the secondary winding currents of the transformer fall to zero. However, the secondary side filter inductor maintains a continuous current through the freewheeling diode 'D_2'. Diode 'D_1' remains off during this mode and isolates the output section of the circuit from the transformer and the input.

Points 'P' and 'N' of the equivalent circuit are effectively shorted due to conduction of diode 'D_2'. The inductor current continues to flow through the parallel combination of the load and the output capacitor. During mode-2, there is no power flow from source to load but still the load voltage is maintained nearly constant by the large output capacitor 'C'. In order to keep the load voltage magnitude within required tolerance band, the converter-switch 'S' is turned on again to end the freewheeling mode and start the next powering mode (mode-1). Under steady state, loss in inductor current and capacitor voltage in mode-2 is exactly made up in mode-1. Control over switch duty ratio, which is the ratio of ON time to (ON + OFF) time, provides the control over the output voltage 'V_O'.

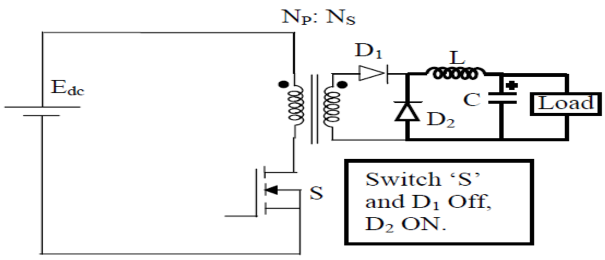

Fig 10: Current path in Mode 2

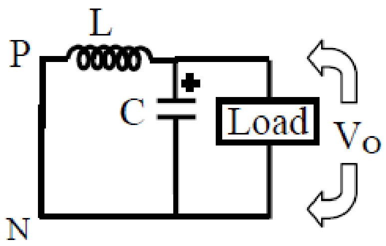

Fig 11: Equivalent circuit in Mode 2

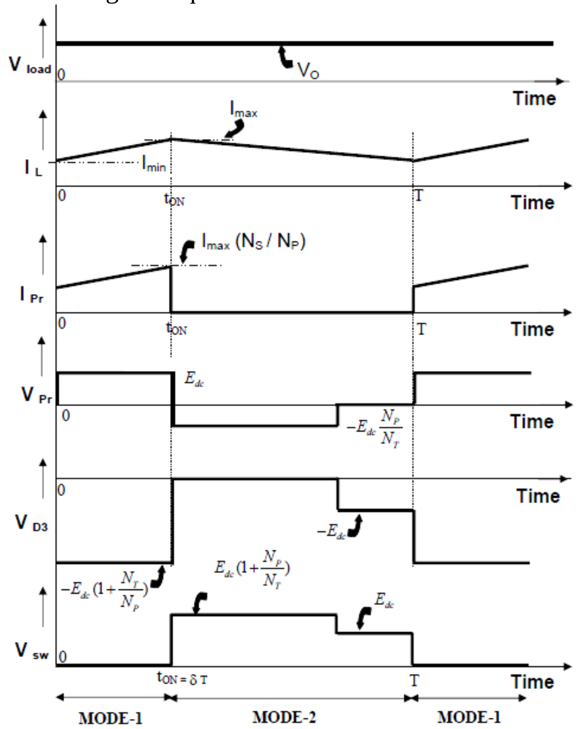

Fig 12: waveforms of Forward Converter

IV. Circuit Analysis

A. Flyback Converter:

The output voltage and hence the lamp current can be regulated by controlling the duty ratio of the flyback converter.

$$V_O = V_F + \frac{d^2 T_s (V_{c1} - V_F) R_e}{2L_P + R_e d^2 T_s}$$

$$i_O = \frac{d^2 T_s (V_{c1} - V_F)}{2L_P + R_e d^2 T_s}$$

B. Forward Converter:

The output voltage and hence the lamp current can be regulated by controlling the duty ratio of the flyback converter.

$$V_O = \delta \left(\frac{N_S}{N_P}\right) E_{dc}$$

$$i_O = \left(\frac{V_O}{R_O}\right)$$

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V. SIMULATION RESULTS

A. Flyback Converter:

The output voltage and hence the lamp current can be regulated by controlling the duty ratio of the flyback converter.

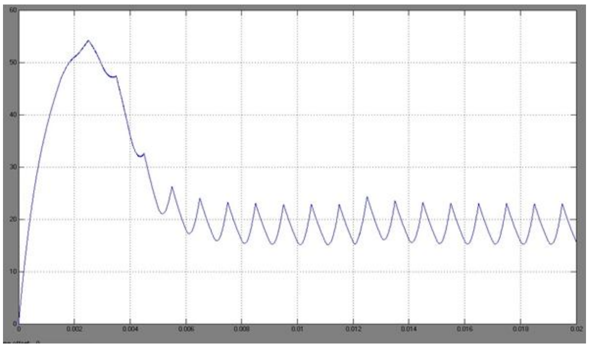

Fig 13: Output Voltage of Flyback converter

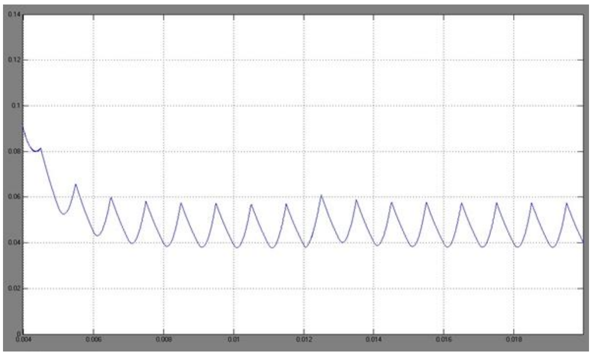

Fig 14: Output Current of Flyback converter

B. Forward Converter:

The output voltage and hence the lamp current can be regulated by controlling the duty ratio of the flyback converter

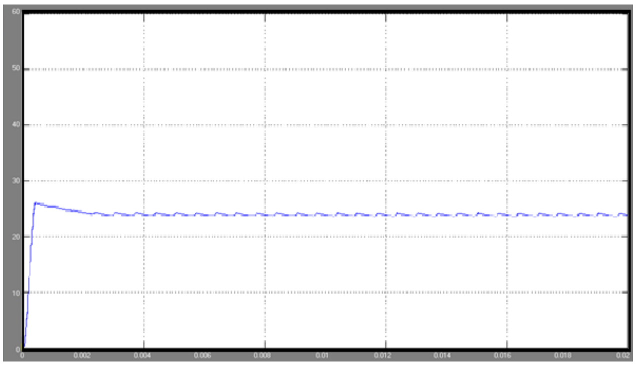

Fig 15: Output Voltage of Flyback converter

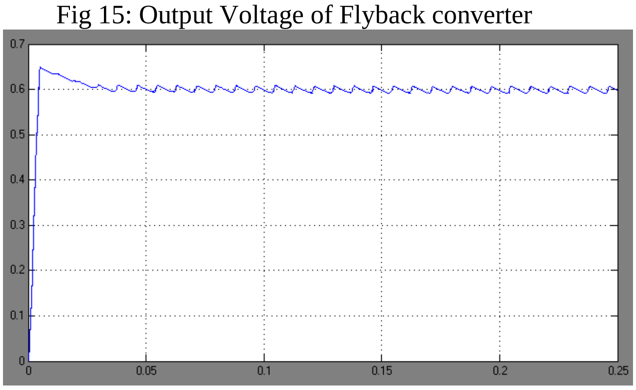

Fig 16: Output Current of Flyback converter

TABLE I : Summary of the elements used in the tow converter circuits

Flyback converter	Forward converter
AC – 110V, 60Hz	AC – 110V, 60Hz
No of LED = 40	No of LED = 40
I_0 = 600 mA	I_0 = 600 mA
L_P = 100 µH	L_P = 2.54 µH
L_S = 1.1 mH	L_S = 6.5 µH
C_1 = 3.3 µF	L_m = 100 µH
C_2 = 3.3 µF	C = 600 µF
Switching Frequency(F_S) = 1 KHz	Switching Frequency(F_S) = 2 KHz
D = 0.5	D = 0.5

VI. CONCLUSION

The efficient approach to the LED lamp driver has been proposed. These driver circuits employs only one active power switch and can accomplish current regulation and PWM dimming by processing a part of the converting power, leading to a high efficiency. This high efficiency feature dominates when the LED lamps consist of a number of LEDs in series. The dimming feature can be realized by means of the PWM control scheme to prevent colour shift during dimming operation. Simulation results on both the driver circuits gave as comparison between the two drivers.

REFERENCES

[1] J. Peck, G. Ashburner, and M. Schratz, "Solid state LED lighting technology for hazardous environments: Lowering total cost of ownership while improving safety, quality of light and reliability,".

[2] E. M. Sa, F. L. M. Antunes, and A. J. Perin, "Low cost self-oscillating ZVS-CV driver for power LEDs," in *Proc. IEEE Power Electron. Spec.*

[3] K. B. Park, C . E. Kim, G . W. Moon, and M . J. Youn, "Non-isolated high step-up converter based on boost integrated half-bridge converter,"

[4] D. Gacio, J. M. Alonso, A. J. Calleja, J. Garcia, and M. Rico-Secades,"A universal-input single-stage high-power-factor power supply for HBLEDs based on integrated buck-flyback converter," *IEEE Trans. Ind.*

[5] Y. C. Li and C. L. Chen, "A novel single-stage high-power-factor AC-to-DC LED driving circuit with leakage inductance energy recycling," *IEEE*

[6] K. I. Hwu, Y. T. Yau, and L. L. Lee, "Powering LED using high-efficiency SR flyback converter," *IEEE Trans.*

[7] Maxim, "Why drive white LEDs with constant current," Sunnyvale, CA, U.S. Aug. 2004, [Online]. Available: http://www.maxim-ic. com/an3256

[8] J. Hasan, D . H. Nguyen, and S. S. Ang, "A RGB-driver for LED display panels," in *Proc. 25th Annu. IEEE Appl. Power Electron. Conf. Expo.*,Feb., 2010, pp. 750–754.

[9] I. H. Oh, "An analysis of current accuracies in peak and hysteretic Current controlled power LED drivers," in *Proc. 23rd Annu. IEEE Appl. Power Electron.*

[10] Y. K. Lo, K. H.Wu, K. J. Pai, and H. J. Chiu, "Design and Implementation of RGB LED drivers for LCD backlight modules," *IEEE Trans. Ind. Electron.*, vol. 56, no. 12, pp. 4862–4871, Dec. 2009.

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