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Research Article

Forward- Fly back

Optimization Forward- Fly back converter using MATLAB

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This study offers an examination of forward and flyback converters by emphasizing important performance metrics, including power factor, efficiency, offset current, and core loss. Each topology has benefits and disadvantages of its own. A comparative assessment of performance characteristics is carried out through conversation and observation to overcome these constraints. The results suggest that combining both topologies with suitable switching devices, such as MOSFETs with quick switching capabilities, may improve total performance. This paper also looks at a suggested merged forward-flyback converter architecture and shows how it could be used to make a single-stage system more efficient and improve its power factor.

Keywords: Forward-Fly back, MOSFET, Power Factor, Efficiency

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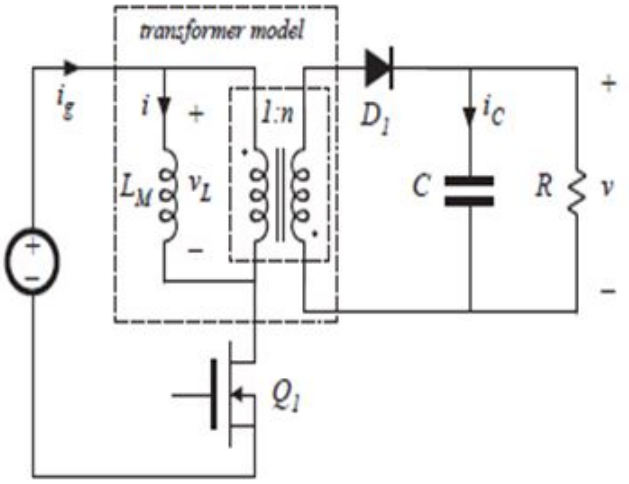
1. Introduction

These Light-emitting diodes, or LEDs, have been widely employed in displays and lighting applications in recent years. It is solely due to the characteristics of LEDs, which include increased efficiency, longevity, and echo-friendliness. As a result, LEDs are increasingly replacing traditional lighting fixtures, including light bulbs and fluorescent lamps [1, 2]. People often use two types of LED drivers: linear and switch-mode regulators [3]. Among them, the linear driver has the benefits of a straightforward circuit design, quick transient response, and precise current control, but it also has significant drawbacks, including poor efficiency and increased heat production. LED applications often use the switch-mode driver due to its high efficiency and power density [4, 5]. Two power conversion stages—a power factor corrector and an isolated DC/DC converter—have been used as drivers for LED lighting [6]. When the input voltage is between 90 and 270 V_{rms}, the first stage has a power factor that is close to 1 and low total harmonic distortion (THD). The second DC/DC stage is used to make sure that the output is tightly controlled and that the AC input and DC output are not connected electrically. The two-stage structure has some significant drawbacks, including a large system size, high manufacturing costs, and poor energy conversion efficiency, even if it can provide a high power factor, strong output control, and excellent ripple voltage [8]-[18]. Because of this, it is typical for single-stage drivers to be used as low-power LED drivers and for two-stage drivers to be used primarily for high-power applications. An electrical device called a rectifier transforms alternating current (AC), which

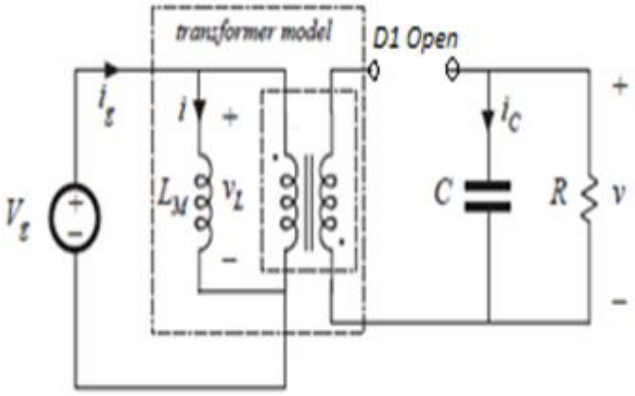
The system regularly switches to direct current (DC), which only travels in one way. Numerous rectifier applications, such as power supplies for computers, televisions, and radios, need a steady, continuous DC, like what a battery would provide. In these applications, an electrical filter—typically a capacitor—smoothes the rectifier's output to provide a constant current. An inverter is a more intricate circuitry device that converts DC to AC, the opposite function.

2. Converter Topology

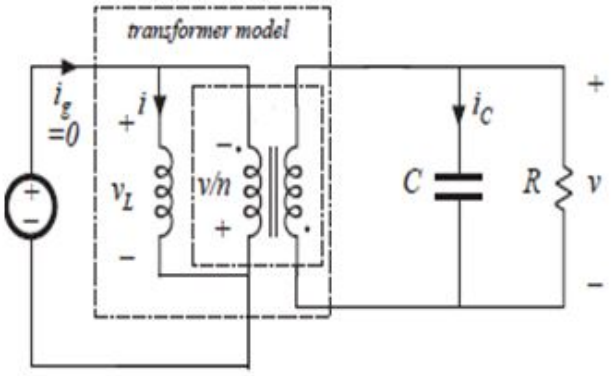
The behavior of most transformer-isolated converters can be adequately understood by modeling the physical transformer with a simple equivalent circuit consisting of an ideal transformer in parallel with the magnetizing inductance. The magnetizing inductance must then follow all of the usual rules for inductors; in particular, the volt-second balance must hold when the circuit operates in a steady state. This implies that the average voltage applied across every winding of the transformer must be zero. Let us replace the transformer of Fig. 1 with the equivalent circuit described above. The circuit of Fig.1(a) is then obtained. The magnetizing inductance *LM* functions in the same manner as inductor *L* of the original buck-boost converter of Fig. 1(a) when transistor *Q1* conducts, energy from the dc source *Vg* is stored in *LM*. When diode *D1* conducts, this stored energy is transferred to the load, with the inductor voltage and current scaled according to the 1:*n* turns ratio.



(a) Fly back converter transformer equivalent circuit model



(b) When diode D1 in Open state



(c) When diode D2 in conducting state

Figure 1: Equivalent Fly back converter circuits

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.

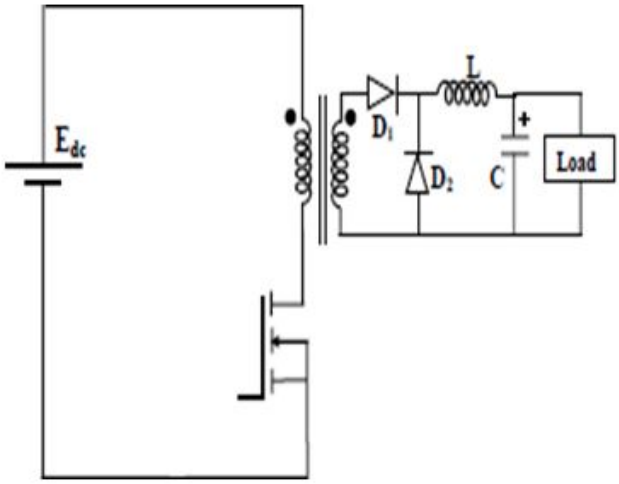


Figure 2: Basic forward converter topology

The forward converter's shown in figure 2. Transformer must be perfect—with no losses, zero magnetizing current, and no leakage fluxes. Here, an illustration has been provided of the fundamental functioning of the circuit using several modes of operation, assuming perfect circuit components. In actuality, a real transformer's limited magnetizing current necessitates the addition of a tertiary winding, which somewhat modifies the circuit architecture.

Reviewing both the conventional converters thoroughly comparative analysis has been made as shown in below table 1.

Table 1: Comparison of Forward Flyback Converter

Characteristics	Conventional fly back converter	Conventional forward converter
Power factor	High	Low
Power conversion efficiency	Low	High
Core losses.	Large	Small
Offset current	High	Low

Considering the pros and cons of conventional forward and fly back converters can be club to overcome the limitations of individual converter.

3. Proposed System

The circuit schematic for the suggested forward flyback converter is seen in Fig. 3. It combines the flyback and forward topologies.

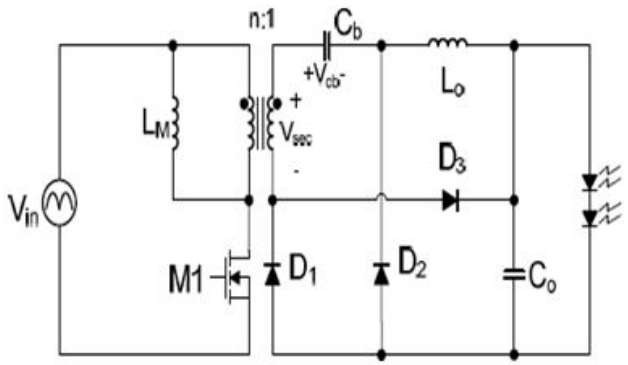


Figure 3: proposed system

As shown in fig3, the proposed system primary side is the same as that of the conventional flyback converter consisting of one power switch (M1) and one transformer. On the other hand, its secondary side consists of one output inductor (L_o) for forward operation, one DC blocking capacitor (C_b) for balancing operation, and three output Diodes (D_1, D_2, D_3). When M1 is conducting, the proposed converter operates as a forward converter. On the other hand, when M1 is blocked, the proposed converter operates as a flyback converter. However, if it is assumed that the proposed converter has no balancing capacitor C_b, the abovementioned forward operation is possible only when the reflected primary voltage Vin/n to the transformer's secondary side is higher than the output voltage Vo. This is because the forward converter is originated from the buck converter. Therefore, the forward-flyback converter operates only as a flyback converter over the range of Vin/n < Vo. Especially, at the minimum input voltage near Vin=90Vrms,

Vin/n is lower than Vo during most of periods and thus, the transformer has a large magnetizing offset current similar to the conventional flyback converter. In this case, the transformer core loss and volume are also as large as those of the traditional flyback converter. On the other hand, if the balancing capacitor Cb is serially inserted with the transformer's secondary side, the average current through Cb during forward operation becomes the same as that during flyback operation by the charge balance principle of Cb.

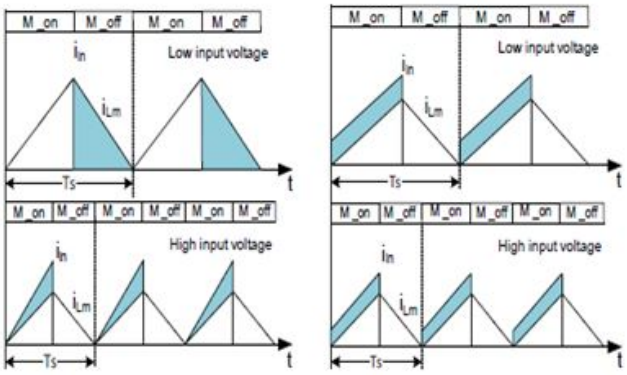
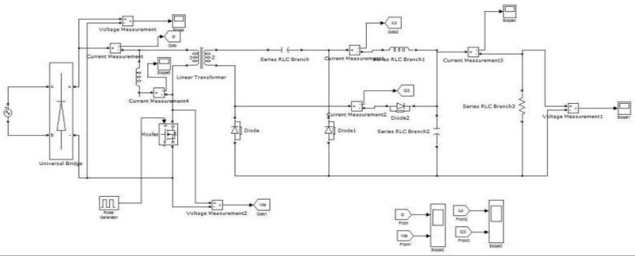


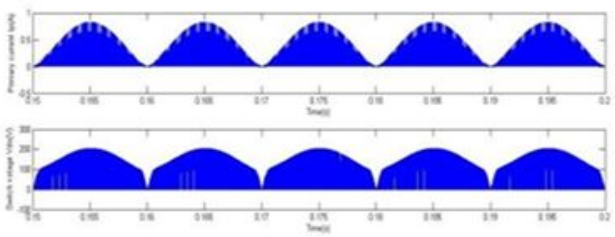
Figure 4: Primary and magnetizing currents of forward-flyback converter according to the input voltage. (a) without balancing capacitor (b) with balancing capacitor

Fig. 4 (a) and (b) show current waveforms without and with balancing capacitor Cb according to the input voltage, respectively. As mentioned earlier, the proposed converter with Cb can operate as both forward and flyback converters over an entire range of input voltage with the aid of Vcb. On the other hand, while the proposed converter without Cb can transfer the input energy to the output side at Vin/n>Vo, it cannot at Vin/n<Vo. As a result, the proposed converter with balancing capacitor Cb features a smaller magnetizing offset current, resulting in smaller core loss and more reduced transformer volume.

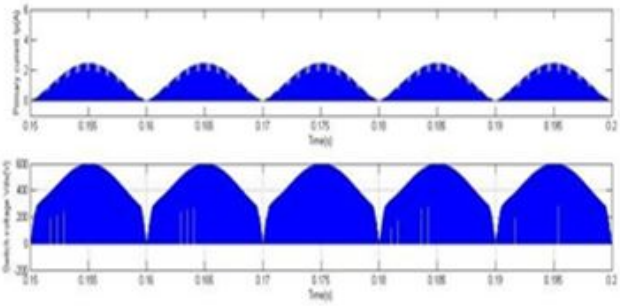
4. Performance Analysis

The proposed converter is simulated using MATLAB at input voltage of 90 and 264V. and following results were drawn.





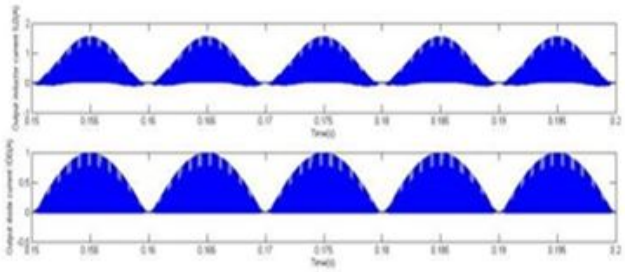
(a) IP and VDS measured at Vin = 90Vrms



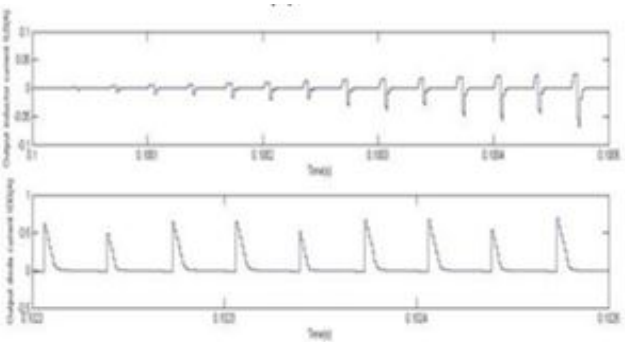
(b) IP and VDS measured at Vin = 264Vrms

Figure 5: Experimental waveforms of transformer primary current

The all corresponding graphs from figure 5 and 6 shows variation of Primary current Ip versus voltage VDS measured at 90 and 264V respectively.

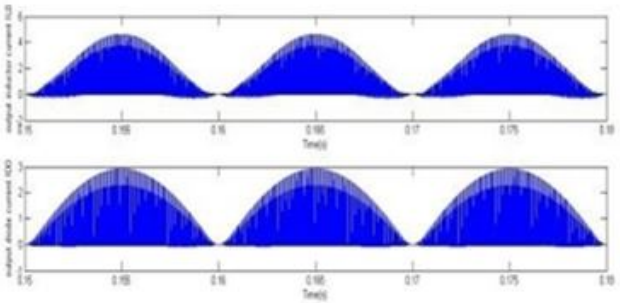


(a) ILO and ID3

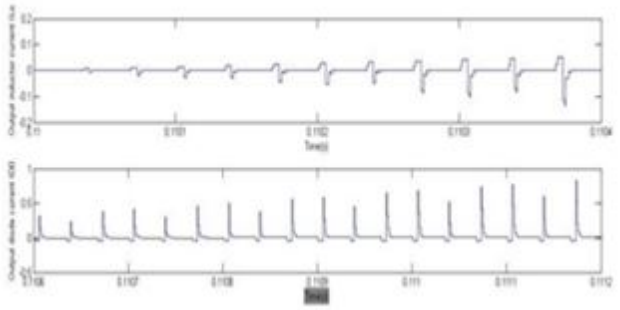


(b) Detail waveforms of ILO and ID3 at low input voltage

Figure 6: Experimental key waveforms of proposed circuit measured at 90Vrms.

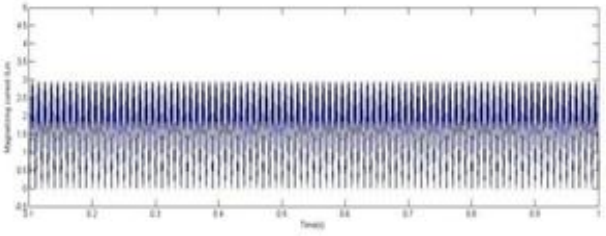


(a) IP and VDS measured at Vin = 264 Vrms

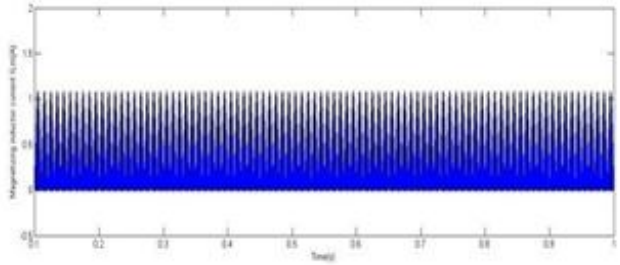


(b) Detailed waveforms of ILO and ID3at low input voltage

Figure 7: Experimental key waveforms of proposed circuit measured at 264Vrms.

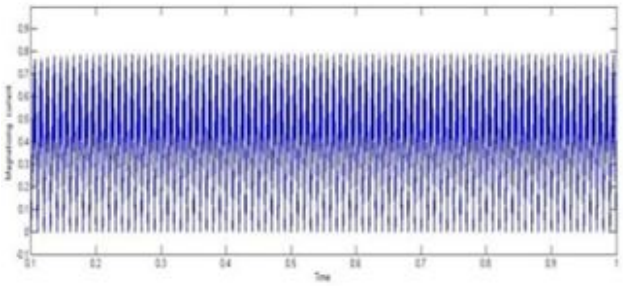


(a) Magnetizing current waveform without balancing capacitor

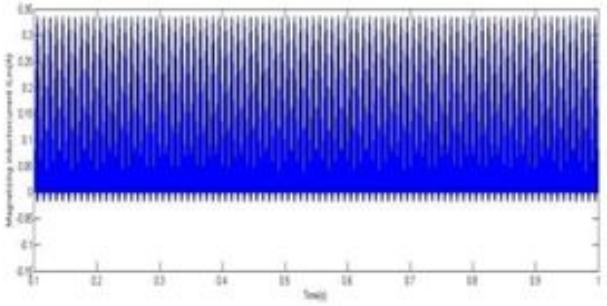


(b) Magnetizing current waveform with balancing capacitor

Figure 8: Simulation waveforms for magnetizing current using pulse generator control at 90 Vrms



(a) Magnetizing current without balancing capacitor



(b) Magnetizing current with balancing capacitor

Figure 8: Simulation waveforms for Magnetizing current using proportional integral control at 90 Vrms

Fig. 7 shows the magnetising current of the proposed forward flyback converter when tested using a proportional integral control at 90 Vrms. When the proposed converter was simulated without a balanced capacitor, as shown in Fig. 8(a), the maximum value of the magnetising current was observed to be approximately 0.8 A at 90 Vrms. On the other hand, Fig. 8(b) displays the waveform of the magnetising current when a balancing capacitor is present at the same voltage. The maximum value of the magnetising current drops to 0.35A.It can be seen in Figs. 7 and 8 that the proposed converter has a lower magnetic offset current than the flyback converter with the help of the balancing capacitor Cb. The proposed system can further reduce this by operating with a proportional integral. As a result, the proposed converter can achieve the smaller transformer core loss and higher efficiency.

5. Conclusion

The suggested converter is dual-control capable, meaning it can run on either pulse generator or PI signals. The findings of the waveforms for main current vs switch voltage and output inductor current versus output diode current are identical in both systems.

The maximum magnetizing current, however, approaches 3A when a balancing capacitor is not used in conjunction with pulse generator control operating at 90V RMS. This drops to 1.1A when a balancing capacitor is included. Applying proportional-integral control further reduces the current to 0.35A. This proves that the technology can efficiently reduce magnetizing current and core losses.

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