

## AN INTEGRATED HALF BRIDGE BASED RESONANT LED DRIVER FOR MULTIPLE LIGHTING APPLICATION

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### ABSTRACT

In this research work, buck integrated half bridge based converter for powering multiple LED lamps is proposed. There are two integrated half bridge resonant converters, and each converter drives two different lamps. The operation of each integrated half bridge converter is independent. The power control in all the LED lamps is achieved using asymmetric duty ratio (ADR) control. The converter features distinctive advantages such as 1) four LED lamps are operated at rated illumination, 2) device switching transitions in half bridge are occurred at zero voltage, 3) the lamps in each half bridge are powered independently, 4) high energy conversion efficiency etc. The use of an LC resonant circuit in the half bridge converter enables the achievement of soft-switching, leading to improved energy efficiency in the proposed LED driver as a result of reduced switching transition power. The results of the steady-state simulation have been presented to confirm the effectiveness of the proposed converter.



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## I. INTRODUCTION

The demand in energy sources across the world poses different challenges to achieve sustainable energy platforms. One of the viable solution for energy sustainability is energy saving, which can be achieved by efficient use of electrical energy. Lighting loads have significant potential to improve energy efficiency [1]. Energy savings can be achieved either by improving the energy conservation of traditional lighting sources or by reducing the capacity of lighting devices using efficient products. Using efficient products, used energy is reduced significantly. In view of this, lighting industry requires an energy efficient lighting sources. A light emitting diode (LED) emerges as an energy-efficient source of illumination. It is a semiconductor device which emits light due to electroluminescence. When the LED junction is forward biased, the electrons from n-side cross the junction and recombine with holes. This recombination produces photons. If the wavelength of emitted photons is in visible spectrum, the exposed semiconductor area emits light [2]. The luminous output of an LED is directly related to the forward current passing through it. The materials used in the fabrication of LED determines the emitted light colour. LEDs are suitable for wide range of applications due to their several advantages such as energy efficient, high operating life, high brightness, environment friendly nature, and compactness [3-6]. The applications of LED based lighting are classified as general illumination, residential lighting, automotive applications, street lighting, signal lighting, decorative lighting, liquid crystal display (LCD) panels, agriculture, communication, biomedical applications, etc [7-9]. LEDs are current controlled or current driven devices as their forward voltage is almost constant for wide current variations. Since the power output from LED is proportional to current flowing through LED, they must be powered from constant current switching power supplies to get required illumination [10], [11]. Many switching power converters operated from utility ac [12], [13] and isolated dc supply [14] have been proposed for LED lighting applications.

The lighting needs for each application vary, but common essential features of LED systems powered by dc sources include high efficiency, current regulation, compact design, multiple lamp support, and dimming capability. Furthermore, the soft-switching capability improves the power density of the driver circuit utilized in LED lighting applications. A full bridge soft-switched topology for multiple LED lighting application is presented [15]. Its features are low switching device current stress, low switching power loss, small conversion power, high energy conversion efficiency, and lamp illumination regulation and pulse width modulation (PWM) dimming operation. In [16], a reduced switch current zero-voltage switched LED converter for multiple lighting loads is given. This article [17] proposes a zero voltage switched full bridge LED driver for future dc-grid applications. Two LED lamps are supplied through interleaving concept, which also helps to reduce switch current and to obtain soft-switching feature. One LED lamp receives controlled power directly without conversion. In article [18], an innovative circuit for driving high power street light LEDs is introduced, utilizing a full bridge configuration. This design minimizes device current stress, enables soft-switching, and achieves high energy efficiency, as well as providing dimming and regulation capabilities at a constant operating current. In research work [19], an independent three-leg soft-switching converter is proposed for LED based lighting application with asymmetrical duty cycle control. A two output series resonant LED driver circuit using three switches is proposed in [20].

Current regulation feature, dimming operation, zero-voltage switching, and steady-state analysis are examined thoroughly. A multi-resonant based converter is presented for wide input LED lighting application in [21]. Apart from fundamental requirements of LED load, output current adjustment with large variation in input voltage, no-lamp protection feature, soft-switching transition, dimming capability, etc., are addressed. In [22], multiple LED lamps are supplied using single inductor based converter circuit is proposed. Authors validate the research work with high dimming range at high dimming frequency. However, more components are used for dimming control. In [23], the authors aim to reduce the processing power required by a converter for LED lighting applications. It is a half bridge based series resonant driver circuit with PWM dimming, illumination current using asymmetric duty operation, zero-voltage switching transition, high conversion efficiency. However driver circuit utilizes extra devices for dimming operation. A multi-output LED driver topology using two power conversion stages for transport lighting application is addressed in [24]. Multi-resonant network is used in the second stage, which operates at resonant frequency at constant duty cycle. Buck-boost converter with multi-phasing concept at the first stage is used for lamp regulation.

But component count and conversion efficiency are limiting factors compared to single stage LED driver circuits. In research work [25], buck-boost integrated series resonant converter with different voltage gains is presented for automotive LED lighting application. Based on the input voltage range, the driver circuit switches to three different configurations with different input-output gains. In this research work, an integrated half bridge based series resonant converter to power multiple LED lamps is presented. Each integrated half-bridge converter operates independently and drives two distinct lamps. The regulation of power in all LED lamps is incorporated by using asymmetric duty ratio (ADR) control. The devices in each half bridge operate at constant duty ratio at rated power. Furthermore, incorporating an LC resonant circuit into the output of the each half bridge assists the realization of zero voltage switching transition. The structure of the document is outlined as follows: section 2 contains a detailed description of the proposed configuration. Section 3 and 4 explore into the working principle and mathematical analysis respectively. The design procedure is provided in section 5. Section 6 is given to present the results and discussions. Lastly, section 7 summarizes the conclusions drawn from the study.

## II. DESCRIPTION OF PROPOSED CONFIGURATION

The proposed integrated half bridge based resonant converter for driving multiple light emitting diode (LED) lamps is depicted in Figure 1. Two half bridge converters are integrated to drive four LED lamps. Half bridge converter-1 consists of a half bridge inverter formed by two power MOSFETs ( $M_1$  &  $M_2$ ), series resonant branch with  $L_{r1}$  and  $C_{r1}$  and full bridge current driven rectifier formed by  $D_{B1}$ -  $D_{B4}$ . The low impedance offered by inductor,  $L_{r1}$  and capacitor,  $C_{r1}$  helps to allow the fundamental component of the half bridge inverter output ( $v_{A0}$ ). The current  $i_{r1}$  is rectified and filtered with capacitor  $C_{02}$  to power the LED lamp-2.  $v_{A0}$  is a periodic voltage of magnitude  $V_{dc1}$  and is applied across series combination inductor,  $L_1$  and LED lamp-1.  $V_{01}$  &  $i_{01}$  and  $V_{02}$  &  $i_{02}$  represent output voltage and current in lamp-1 and lamp-2 respectively. Half bridge converter-2 consists of a half bridge inverter formed by two power MOSFETs ( $M_3$  &  $M_4$ ), series resonant branch with  $L_{r2}$  and  $C_{r2}$  and full bridge current driven rectifier formed by  $D_{B5}$ -  $D_{B8}$ . The fundamental component of the half bridge inverter output ( $v_{B0}$ ) is utilized due to the impedance offered by inductor,  $L_{r2}$  and capacitor,  $C_{r2}$ . The current  $i_{r2}$  is rectified and filtered with capacitor  $C_{04}$  to power the LED lamp-4.  $v_{B0}$  is a periodic voltage of magnitude  $V_{dc2}$  and is applied across series combination inductor,  $L_3$  and LED lamp-3.  $V_{03}$  &  $i_{03}$  and  $V_{04}$  &  $i_{04}$  represent output voltage and the current in lamp-3 and lamp-4 respectively.  $v_{L1}$  and  $v_{L3}$  stand for the voltages across inductor  $L_1$  and  $L_3$ , respectively. The polarity on  $v_{L1}$  &  $v_{L3}$  decides charging and discharging in  $L_1$  &  $L_3$  respectively.

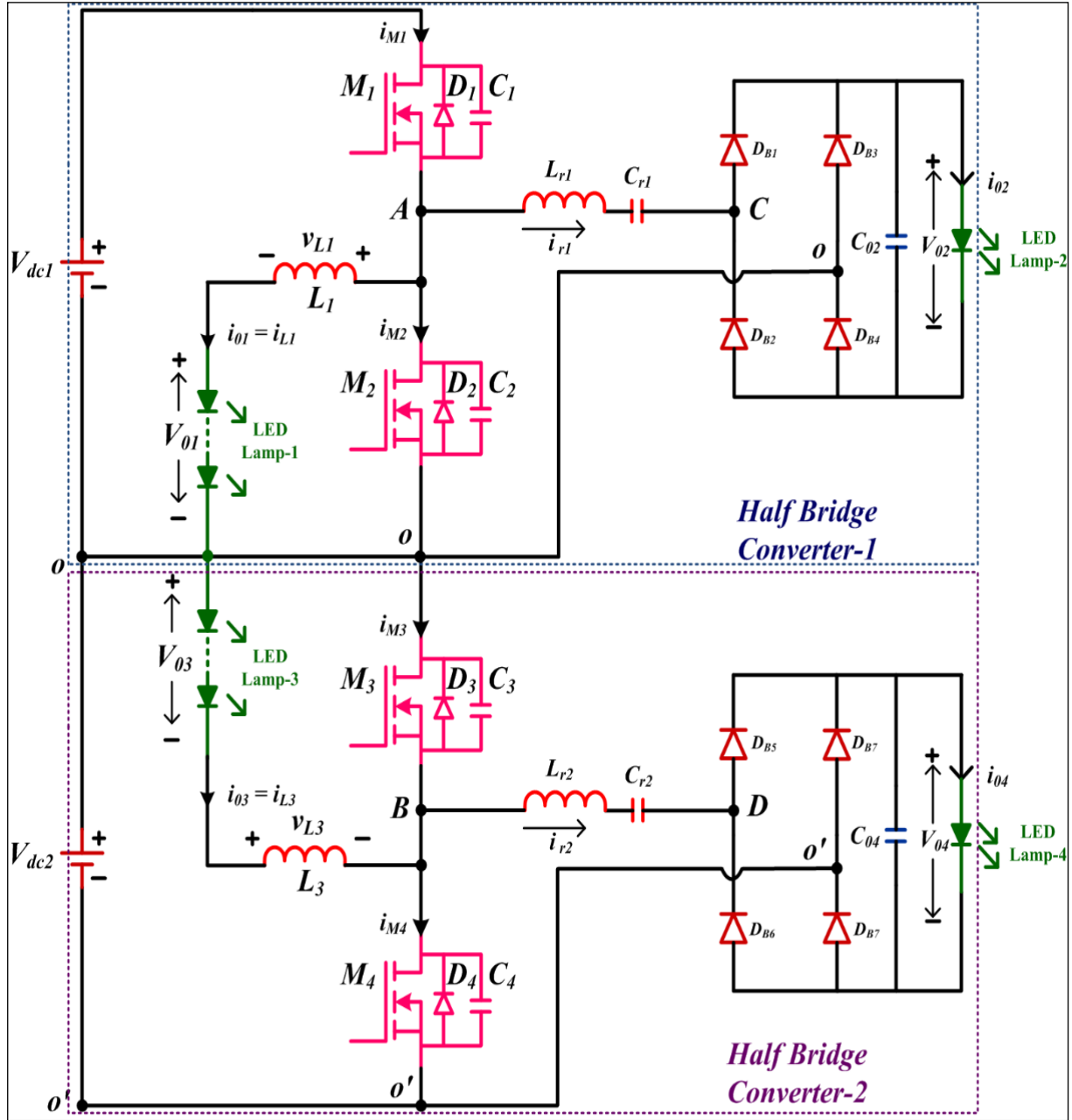


Figure 1: Circuit diagram of proposed half bridge based LED driver.  
Source: Authors, (2026).

### III. PRINCIPLE OF OPERATION

Figure 2 shows the operating waveforms related to proposed integrated half bridge resonant LED driver. In half bridge converter-1, the gate voltages  $v_{g1}$  and  $v_{g2}$  are complementary to each other and devices  $M_1$  and  $M_2$  are operated with a duty ratio  $D_1$  and  $(1-D_1)$  at time period  $T$  respectively. Similarly, in half bridge converter-2, the gate voltages  $v_{g3}$  and  $v_{g4}$  are complementary to each other and  $M_3$  and  $M_4$  are operated with a duty ratio  $D_3$  and  $(1-D_3)$  at the same time period  $T$  respectively. Device  $M_1$  (or  $M_2$ ) and  $M_3$  (or  $M_4$ ) can be operated either in phase or unequal turn-on time. However, in this section, different operating modes are given with equal device turn-on time, i.e.  $D_1T = (1-D_1)T = D_3T = (1-D_3)T$ .

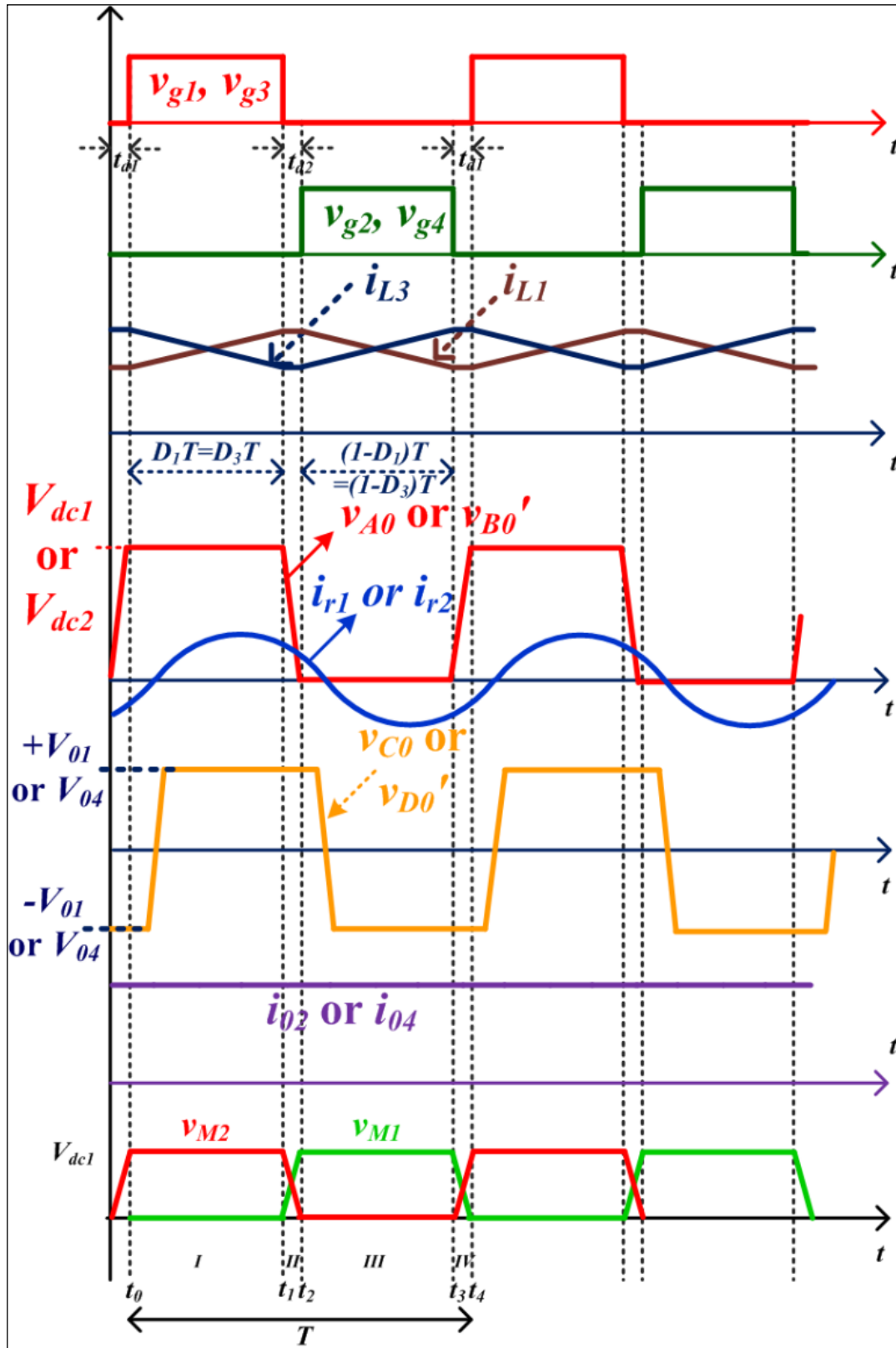


Figure 2: Operating waveforms (a) half bridge related waveforms (b) buck-boost related waveforms.  
Source: Authors, (2026).

### III.1 MODE-1 ( $T_0 - T_1$ )

At time  $t = t_0$ , switches  $M_1$  and  $M_3$  are started conduction using gate voltage  $v_{g1}$  and  $v_{g3}$  respectively. Figure 3 (a) displays the conduction circuit. In this mode, voltage across inductor  $L_1$  is positive and LED lamp-1 allows the current  $i_{L1}$  to charge linearly through  $M_1$ . Simultaneously, voltage,  $V_{L2}$  across inductor  $L_2$  is negative and lamp-3 allows the current  $i_{L2}$  to discharge linearly through  $M_3$ . When  $M_1$  is conducting in half bridge converter-1, voltage  $v_{A0}$  is  $+V_{dc1}$ . Consequently, the series resonant circuit comprising  $L_{r1}$  and  $C_{r1}$  provides low impedance to the fundamental component of  $v_{A0}$ . As a result, an alternating current  $i_{r1}$  is produced, which is then rectified by bridge diodes  $D_{B1}$  and  $D_{B4}$  to supply power to lamp-2.

Similarly, in half bridge converter-2, when  $M_3$  is conducting voltage  $v_{B0'}$  is  $+V_{dc2}$ . Thus, in the series resonant circuit with  $L_{r2}$  and  $C_{r2}$ , the fundamental component of  $v_{B0'}$  is utilized to generate resonant current  $i_{r2}$  is generated, which is rectified through  $D_{B5}$  and  $D_{B8}$  to power lamp-4.  $M_1$  conducts the sum of  $i_{01}$  and  $i_{r1}$  and  $M_3$  conducts the difference between  $i_{r2}$  and  $i_{03}$ . In this mode, voltage across output capacitance of  $M_2$  is  $+V_{dc1}$  and voltage across output capacitance of  $M_4$  is  $+V_{dc2}$ . This mode concludes at  $t = t_1$ .

### III.2 MODE-2 ( $T_1 - T_2$ )

At  $t = t_1$ , gate voltages,  $v_{g1}$  &  $v_{g3}$  are removed and  $v_{g2}$  &  $v_{g4}$  are not yet given to turn on  $M_2$  and  $M_4$  respectively. The resonant current ( $i_{r1}$  &  $i_{r2}$ ), lamp-1 current ( $i_{L1}$ ) and lamp-3 current ( $i_{L3}$ ) prefer to flow through device output capacitances. The conduction circuit is given in Figure 3(b). Both device  $M_1$  and  $M_2$  in half-bridge converter-1 are not conducting, thus output capacitance ( $C_1$ ) of  $M_1$  charges from zero to  $V_{dc1}$  due to the current  $(i_{r1} + i_{L1})/2$  through it. Similarly,  $C_2$  of device  $M_2$  carries the sum of remaining half of  $i_{r1}$  and  $i_{L1}$ , hence it discharges from  $V_{dc2}$  to zero. When voltage across  $C_2$  is -0.7 V, internal diode of  $M_2$  will be forward biased. Gate voltage  $v_{g2}$  for device  $M_2$  can be applied after  $D_2$  is forward biased for zero voltage switching.  $M_1$  is already turned off at zero voltage. In the similar process, the current  $(i_{r2} - i_{L3})/2$  in  $C_3$  and  $(i_{r2} - i_{L3})/2$  in  $C_4$  make the devices  $M_3$  and  $M_4$  through zero voltage switching transitions in half-bridge converter-2. At  $t = t_2$ , mode-3 is initiated.

### III.3 MODE-3 ( $T_2 - T_3$ )

At time  $t = t_2$ , switches  $M_2$  and  $M_4$  are started conduction using gate voltage  $v_{g2}$  and  $v_{g4}$  respectively. Figure 4 (a) displays the conduction circuit. In this mode, voltage across inductor  $L_1$  is  $-V_{01}$  and LED lamp-1 allows the current  $i_{L1}$  to discharge linearly through  $M_2$ . Simultaneously, voltage,  $V_{L2}$  across inductor  $L_2$  is  $V_{dc2} - V_{03}$  and lamp-3 allows the current  $i_{L2}$  to charge linearly through  $M_4$ . When  $M_2$  is conducting in half bridge converter-1, voltage  $v_{A0}$  is zero. However, resonant current,  $i_{r1}$  flows through  $D_{B2}$  and  $D_{B3}$  to power lamp-2 due to the fundamental component of  $v_{A0}$ . Similarly, in half bridge converter-2, when  $M_4$  is conducting voltage  $v_{B0'}$  is zero. Thus, due to the fundamental component of  $v_{B0'}$ , resonant current,  $i_{r2}$  conducts through  $D_{B6}$  and  $D_{B7}$  to power lamp-4.  $M_2$  conducts the difference of  $i_{01}$  and  $i_{r1}$  and  $M_4$  conducts the sum of  $i_{r2}$  and  $i_{03}$ . In this mode, voltage across output capacitance of  $M_1$  is  $+V_{dc1}$  and voltage across output capacitance of  $M_3$  is  $+V_{dc2}$ . This mode concludes at  $t = t_3$ .

### III.4 MODE-4 ( $T_3 - T_4$ )

During ( $t_3 - t_4$ ) interval, gate voltages ( $v_{g2}$  &  $v_{g4}$ ) to switch  $M_2$  and  $M_4$  are removed at zero voltage and ( $v_{g1}$  &  $v_{g3}$ ) are not applied to turn on switches  $M_1$  and  $M_3$ . Figure 4(b) illustrates mode-4 operation. All the devices  $M_1$ - $M_4$  are in off state, the current  $i_{r1}$ ,  $i_{r2}$ ,  $i_{L1}$  and  $i_{L3}$  are equally divided and flows through device output capacitance  $C_1$ - $C_4$ . The process of turning on of ( $M_1$  &  $M_3$ ) and turning off of ( $M_2$  &  $M_4$ ) is similar to that of mode-2.

## IV. ANALYSIS OF PROPOSED CONVERTER

The analysis of proposed integrated half based resonant LED driver configuration is provided under steady state ideal conditions.

### IV.1 ANALYSIS OF LAMP-1 AND LAMP-3

The switches in each half bridge are operated with equal duty ratio at fixed switching period ( $T$ ). The relationship between the lamp's output voltage and the input voltages ( $V_{dc1}$  &  $V_{dc2}$ ) can be determined from mode-1 and mode-3 with neglected dead times. When switch  $M_1$  and  $M_3$  are conducting, LED lamp-1 is powered from input voltage ( $V_{dc1}$ ) of half bridge converter-1 and lamp-3 receives the stored energy in  $L_3$ . When switch  $M_2$  and  $M_4$  are conducting, LED lamp-1 receives the stored energy in  $L_1$  and lamp is powered from input voltage ( $V_{dc2}$ ) of half bridge converter-2. To simplify the analysis, the conduction duration of each switch in the half bridge is approximately equal to its OFF time duration. The application of volt-sec balance in inductor voltages of  $L_1$  and  $L_3$  results the output voltages for the lamps as

$$V_{01} = V_{dc1} D_1 \quad (1)$$

$$V_{03} = V_{dc2} D_3 \quad (2)$$

From the operating waveforms shown in Figure 2, the ripple current is represented in  $L_1$  and  $L_3$  as

$$\Delta i_{L1} = \frac{V_{dc1} - V_{01}}{L_1} D_1 T = \frac{V_{01}}{L_1} (1 - D_1) T \quad (3)$$

$$\Delta i_{L3} = \frac{V_{03}}{L_3} D_3 T = \frac{V_{dc2} - V_{03}}{L_3} (1 - D_3) T \quad (4)$$

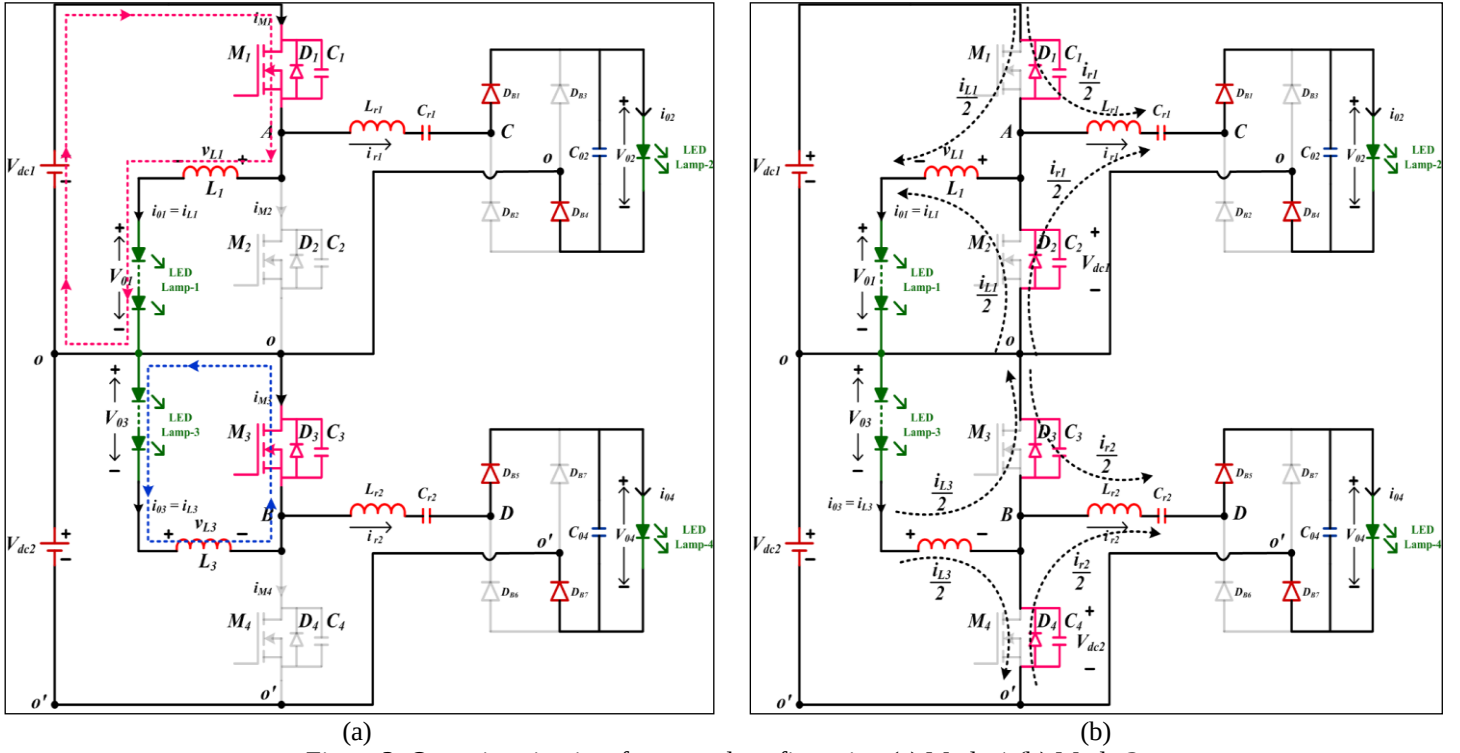


Figure 3: Operative circuits of proposed configuration (a) Mode-1 (b) Mode-2.

Source: Authors, (2026).

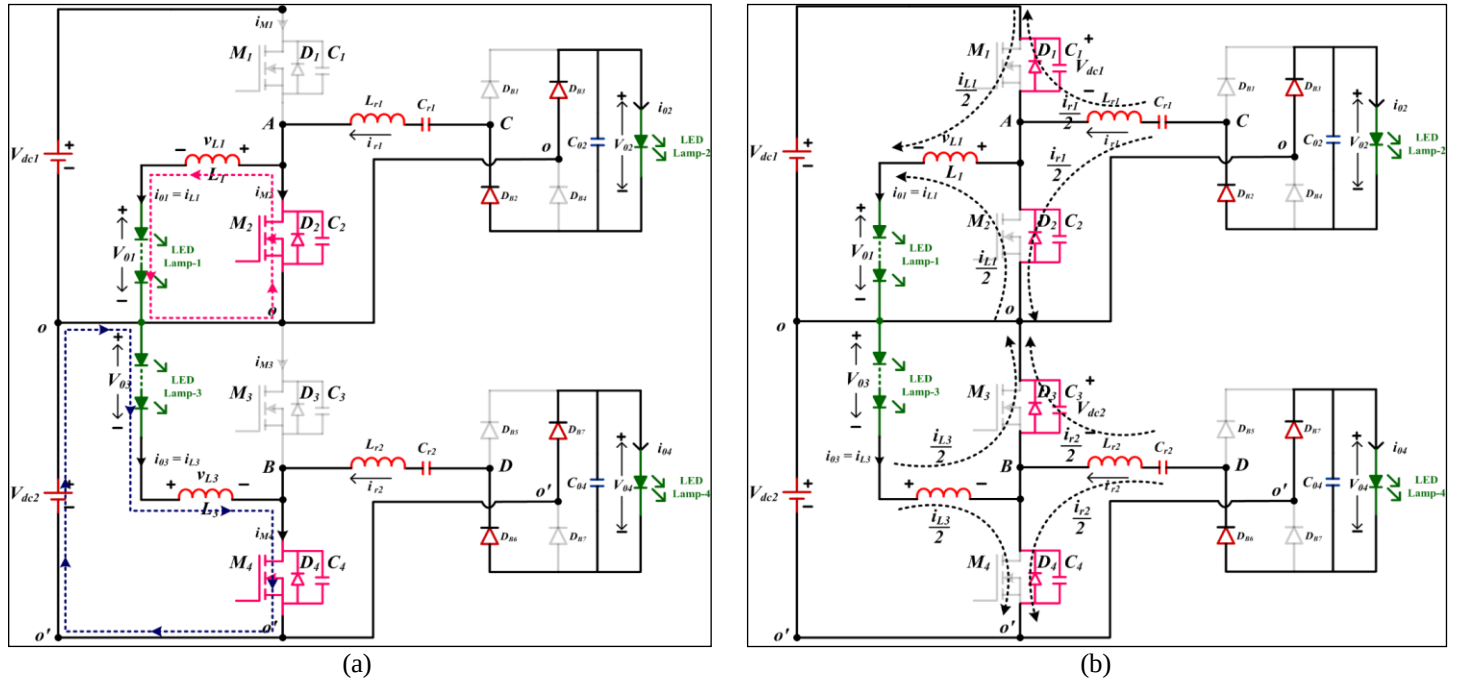


Figure 4: Operative circuits of proposed configuration (a) Mode-3 (b) Mode-4.

Source: Authors, (2026).

#### IV.2 ANALYSIS OF LAMP-2 AND LAMP-4

In the proposed converter, half bridge series resonant circuits are used to power lamp-2 and lamp-4. The mathematical approach is provided to find output voltage of half bridge converter-1 and similar approach can also be used to find output voltage of LED lamp-4. In half bridge converter-1,  $v_{A0}$ , which is a periodic voltage of magnitude  $V_{dc1}$ , is applied across series resonant circuit formed by resonant inductor,  $L_{r1}$ , capacitor,  $C_{r1}$  and diode bridge rectifier ( $D_{B1}$ - $D_{B4}$ ). The resonant circuit allow only fundamental components. The relation between output voltage,  $V_{O2}$  of lamp-2 and input voltage,  $V_{dc1}$  is calculated by considering fundamental ac components [26] presented in the half bridge inverter output voltage,  $v_{A0}$  and diode bridge rectifier input voltage  $v_{CO}$ . The ac equivalent circuit of half bridge converter-1 is shown in Figure 5(a). The ac resistance offered by diode bridge rectifier is represented as  $R_{ac2}$ .  $X_{Lr1}$  and  $X_{Cr1}$  represent reactance offered by  $L_{r1}$  and  $C_{r1}$  respectively. From Figure 5(a), the relation between  $V_{O2}$  and  $V_{dc1}$  is derived as follows:

$$\frac{V_{C0}}{V_{A0}} = \frac{R_{ac2}}{R_{ac2} + j(X_{Lr1} - X_{Cr1})} = \frac{1}{1 + j \left( \frac{X_{Lr1} - X_{Cr1}}{R_{ac2}} \right)} \quad (5)$$

Note that  $V_{A0}$  is the fundamental component of the periodic voltage applied to series resonant circuit and  $V_{C0}$  is the fundamental component of square wave voltage of magnitude  $V_{02}$  across  $R_{ac2}$ . Figure 5(b) shows the calculation of  $R_{ac2}$  and is expressed as

$$R_{ac2} = \frac{V_{C0}(rms)}{I_{r1}(rms)} = \frac{4V_{02}}{\sqrt{2}\pi} \cdot \frac{\pi I_{02}}{2\sqrt{2}} = \frac{8}{\pi^2} \frac{V_{02}}{I_{02}} = \frac{8}{\pi^2} R_{lamp2} \quad (6)$$

Where  $R_{lamp2}$  is the resistance offered by lamp-2 at  $V_{02}$  and  $I_{02}$ . And

$$X_{Lr1} = 2\pi f L_{r1} \quad (7)$$

$$X_{Cr1} = \frac{1}{2\pi f C_{r1}} \quad (8)$$

The selectivity of the series resonant current formed by  $L_{r1}$ , and  $C_{r1}$  is denoted by using quality factor ( $Q_1$ ), and it is expressed as

$$Q_1 = \frac{\omega_{01} L_{r1}}{R_{lamp2}} = \frac{1}{\omega_{01} C_{r1} R_{lamp2}} \quad (9)$$

where  $\omega_{01}$  is resonant frequency of half bridge converter-1 in radians per seconds and it is given by

$$\omega_{01} = 2\pi(f_{01}) = \frac{1}{\sqrt{L_{r1} C_{r1}}} \text{ rad/sec} \quad (10)$$

$$f_{01} = \frac{1}{2\pi\sqrt{L_{r1} C_{r1}}} \text{ Hz} \quad (11)$$

By substituting Eqn. (6), (7), (8) and (9) in Eqn. (5), the relation between  $V_{02}$  and  $V_{dc1}$  is finally expressed as

$$\frac{V_{C0}}{V_{A0}} = \frac{4V_{02}/\pi}{2V_{dc1}/\pi} = \frac{V_{02}}{V_{dc1}} = \frac{1}{1 + j \frac{\pi^2}{8} Q_1 \left( \frac{f}{f_{01}} - \frac{f_{01}}{f} \right)} \quad (12)$$

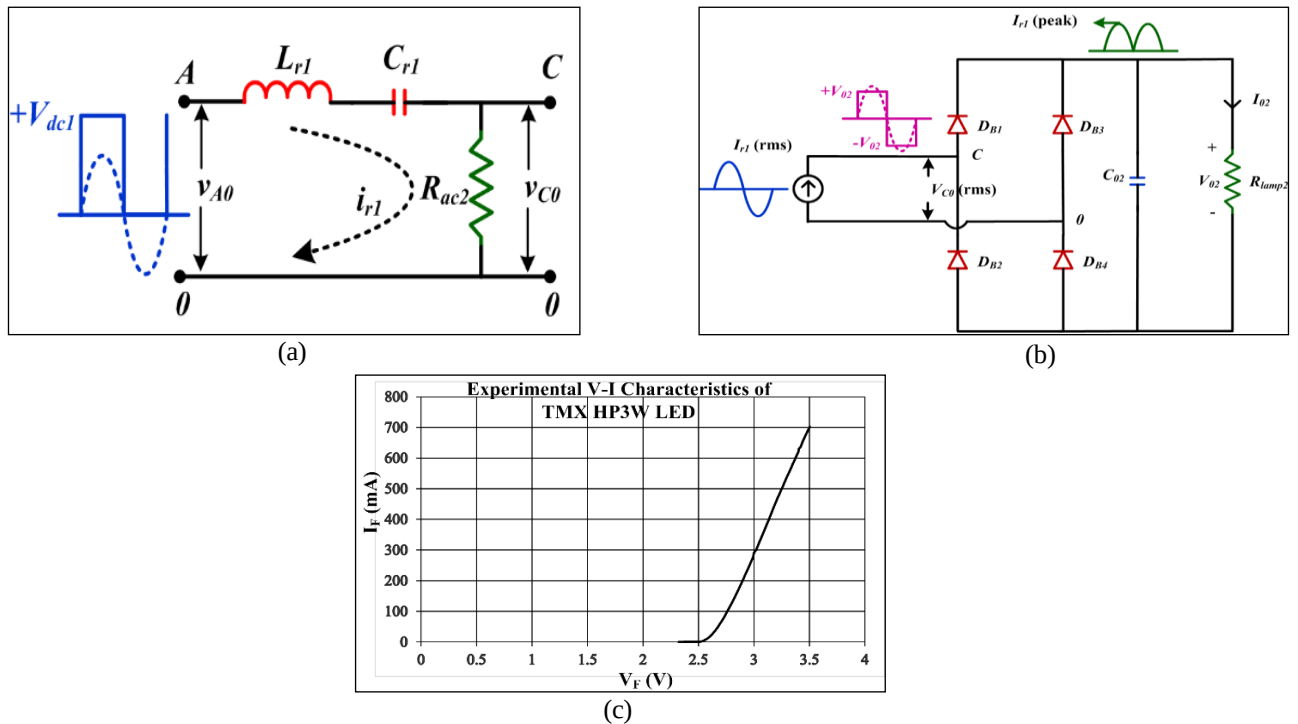


Figure 5: (a) AC equivalent circuit (b) Equivalent circuit for  $R_{ac2}$  (c) Static characteristics of TMX HP 3WLED. Source: Authors, (2026).

## V. DESIGN PROCEDURE

In the proposed LED configuration, LED lamp-1 and lamp-3 are identical. And, lamp-2 & lamp-4 are identical. An LED's equivalent circuit [27] is necessary to determine the parameters associated with lamps. The proposed configuration is validated with equivalent circuit of TMX HP 3WLEDs and their voltage and current characteristics are illustrated in Figure 5 (c). From the characteristics, 2.3 V is observed as threshold voltage ( $V_{th}$ ) of the LED. Each LED in lamp-1 and lamp-3 is operated at a voltage of 3.42 V and a current of 590 mA. In LED lamp-1 and lamp-3, there are two parallel strings, with each string containing 7 LEDs connected in series. Therefore lamp-1 and lamp-3 are operated at a forward voltage ( $V_{01}$  (or)  $V_{03}$ ) of 23.94 V, forward current ( $i_{01}$  (or)  $i_{03}$ ) of 1.18 A and power rating of 28 W. Similarly, each LED in lamp-2 and lamp-4 is operated at a voltage of 3.3 V and a current of 525 mA. Four parallel strings are connected in lamp-2 & 4, and each string contains a series connection of 6 LEDs. Therefore lamp-2 and lamp-4 are operated at a forward voltage ( $V_{02}$  (or)  $V_{04}$ ) of 19.8 V, forward current ( $i_{02}$  (or)  $i_{04}$ ) of 2.1 A and power rating of 42 W. Lamp-2 and lamp-4 start allow current above their cut-in voltage and it is found to be 13.8 V.

### V.1 CALCULATION OF INPUT VOLTAGE:

The input voltage applied to half bridge converter-1 and half bridge converter-2 can be determined using equation (1) and (2) respectively. With  $D_1 = D_3 = 0.5$ ,  $V_{01} = V_{03} = 23.94$  V and  $V_{dc1}$  &  $V_{dc2}$  are calculated as

$$V_{dc1} = V_{dc2} = \frac{V_{01} \text{ (or) } V_{03}}{D_1 \text{ (or) } D_3} = \frac{23.94}{0.5} \cong 48 \text{ V}$$

### V.2 CALCULATION OF THE VALUE OF INDUCTOR $L_1$ AND $L_3$

Rearranging equation (3), value of  $L_1$  is expressed as

$$L_1 = \frac{V_{dc1} - V_{01}}{\Delta i_{L1}} D_1 T \quad (13)$$

With  $V_{dc1}$  of 48 V,  $V_{01}$  of 23.94 V, switching period  $T$  of 8  $\mu$ s,  $D_1$  of 0.5, and the current ripple  $\Delta i_{L1}$  is 13 % of  $i_{01}$ , from equation (13), the inductor  $L_1$  is calculated as

$$L_1 = \frac{48 - 23.94}{0.13 \times 1.18} (0.5 \times 8 \times 10^{-6}) \cong 626 \mu H$$

To calculate the value of  $L_1$  equation (4) is rearranged as

$$L_3 = \frac{V_{dc2} - V_{03}}{\Delta i_{L3}} (1 - D_3) T \quad (14)$$

With  $V_{dc2}$  of 48 V,  $V_{03}$  of 23.94 V, switching period  $T$  of 8  $\mu$ s,  $D_3$  of 0.5, and the current ripple  $\Delta i_{L3}$  is 13 % of  $i_{01}$ , from equation (14), the inductor  $L_3$  is calculated as

$$L_3 = \frac{48 - 23.94}{0.13 \times 1.18} (1 - 0.5) \cdot 8 \times 10^{-6} \cong 626 \mu H$$

### V.3 CALCULATION OF HALF BRIDGE RESONANT CONVERTER PARAMETERS

From equation (11), the product of  $L_{r1}$  and  $C_{r1}$  is expressed as

$$L_{r1} C_{r1} = \left[ \frac{1}{2\pi f_{01}} \right]^2 \quad (15)$$

After selecting  $f_{01}$  as 113.64 kHz, equation (15) is expressed as

$$L_{r1} C_{r1} = 1.961 \times 10^{-12} \quad (16)$$

Equation (9) is rearranged as

$$Q_1 = \frac{1}{R_{lamp2}} \sqrt{\frac{L_{r1}}{C_{r1}}} \quad (17)$$

With  $Q_1 = 3$  and  $R_{lamp2} = 9.43 \Omega$ , from Eqn. (16) and (17), the value of  $C_{r1}$  and  $L_{r1}$  are obtained as 47 nF and 40  $\mu$ H respectively. With the similar approach shown above, the value of  $C_{r2}$  and  $L_{r2}$  are also selected as 47 nF and 40  $\mu$ H respectively. To reduce ripple current less than 10% of selected operating current,  $C_{02}$  and  $C_{04}$  are selected as 10  $\mu$ F.

Table 1: Component values of the proposed configuration.

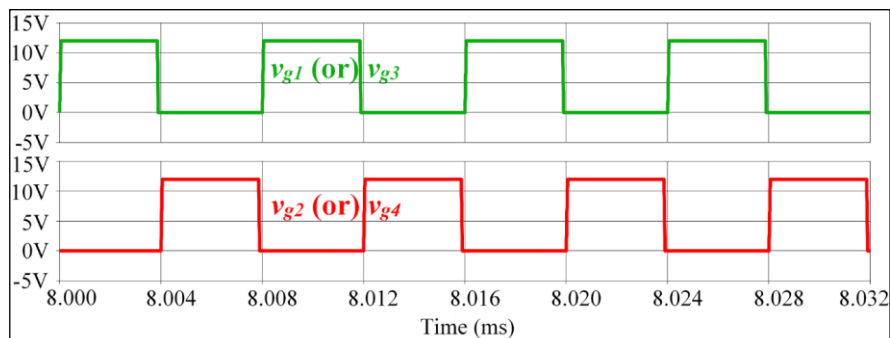
|                                                      |             |
|------------------------------------------------------|-------------|
| Input voltage, $V_{dc1}$ & $V_{dc2}$                 | 48 V        |
| Switching frequency, $f_s$                           | 125 kHz     |
| Resonant frequency, $f_{01,02}$                      | 113.64 kHz  |
| Resonant inductor, $L_{r1,r2}$                       | 40 $\mu$ H  |
| Resonant capacitor $C_{r1,r2}$                       | 47 nF       |
| Inductor, $L_{1,3}$                                  | 626 $\mu$ H |
| Lamp-1 and lamp-3 voltage, $V_{01,03}$               | 23.94 V     |
| LED lamp-2 and lamp-4 voltage, $V_{02,04}$           | 19.8 V      |
| Current in lamp-1 and lamp-3, $i_{01}$ (or) $i_{03}$ | 1.18 A      |
| Current in lamp-2 and lamp-4, $i_{02,04}$            | 2.1 A       |
| $P_{01,03}$                                          | 28 W        |
| $P_{02,04}$                                          | 42 W        |
| Switching devices used                               | IRF 640N    |

Source: Authors, (2026).

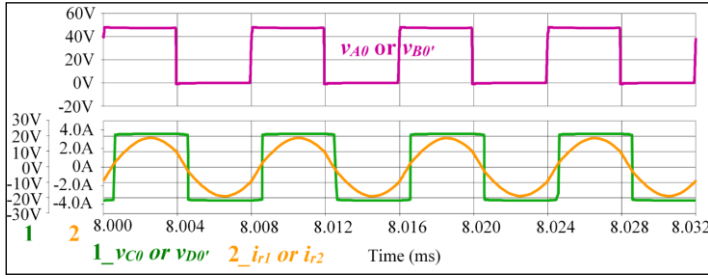
## VI. RESULTS AND DISCUSSIONS

The proposed buck integrated half bridge based LED driver is simulated in the OrCAD PSpice environment. Table 1 provides the LED lamp voltage, current, power ratings, and component values. The configuration is designed to power four lamps of total 140 W and has been verified through OrCAD PSpice simulation software. At rated illumination, the voltage and current waveforms in different components are given and discussed below. Figure 6 (a) shows the gate voltages of the switches M1 – M4. It indicates that devices in half bridge converter-1 and converter-2 operate at 125 kHz with  $D1 = 0.5$  and  $D3 = 0.5$ . Figure 6 (b) illustrates output voltages ( $v_{A0}$  &  $v_{B0}$ ) of half bridge inverters, resonant currents ( $i_{r1}$  &  $i_{r2}$ ) and input voltages ( $v_{C0}$  &  $v_{D0}$ ) of diode bridge rectifiers. It clearly shows that half bridge inverter outputs are periodic voltages. Resonant currents generated lag the corresponding half bridge inverter output voltage and are in phase with corresponding input voltage of diode bridge rectifier. Figure 7 shows voltage, as well as the current in all the LED lamps. It is observed that all the lamps are illuminated at selected operating values. In Figure 8, switching waveforms of devices in both half bridge are shown. It is observed that switching transitions of devices M1 – M4 are completed at zero voltage within the dead time. At full illumination level, the efficiency of the proposed resonant LED driver is found to be 93.58 %. In the proposed converter, the power through lamp-1 and lamp-2 can be controlled simultaneously by changing the duty ratio of switch M1.

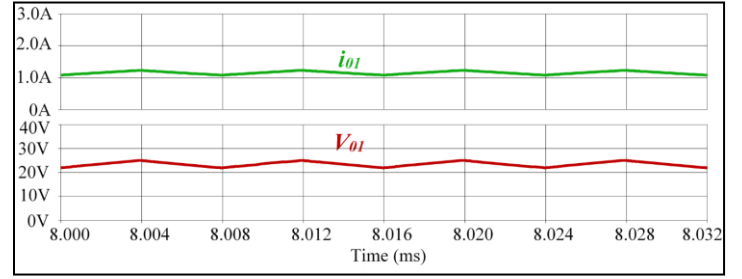
Similarly, the illumination from lamp-3 and lamp-4 can be controlled by varying the duty ratio of M3. At  $D1 = 0.4$  and  $D3 = 0.6$ , the voltage and current waveforms in different components are given and discussed below. Figure 9 shows the gate voltages of the switches M1 – M4, output voltages ( $v_{A0}$  &  $v_{B0}$ ) of half bridge inverters, resonant currents ( $i_{r1}$  &  $i_{r2}$ ) and input voltages ( $v_{C0}$  &  $v_{D0}$ ) of diode bridge rectifiers. It clearly shows that half bridge inverter outputs are periodic voltages with different pulse widths. The magnitudes of resonant currents generated are reduced in both half bridge converters. Figure 10 represents voltage and current in all the four LED lamps at reduced power level. It is observed that lamp-1 illuminates at 16.46 W, lamp-2 is powered at 35.75 W, lamp-3 also illuminates at 16.46 W and lamp-4 is also supplied with 35.75 W. Switching waveforms at the operating condition of devices are provided in Figure 11. It clearly indicates that switching transitions of switches M1 – M4 are completed at zero voltage. The power consumed by all the lamps is 104.52 W and the efficiency of the proposed resonant LED driver is calculated to be 92.64 %. The power supplied to all lamps can be changed by varying duty ratio  $D1$  and  $D3$ . At various power levels, energy efficiency curve of the converter is shown in Figure 10(d) and high efficiency is obtained at different operating conditions.



(a)

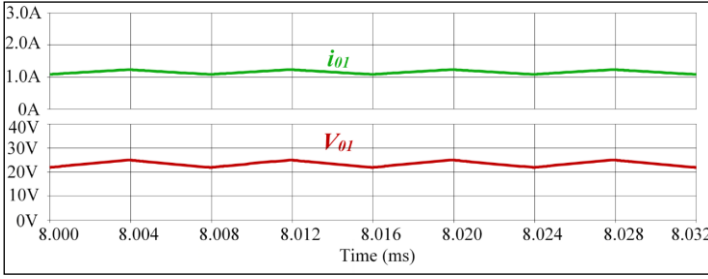


(b)

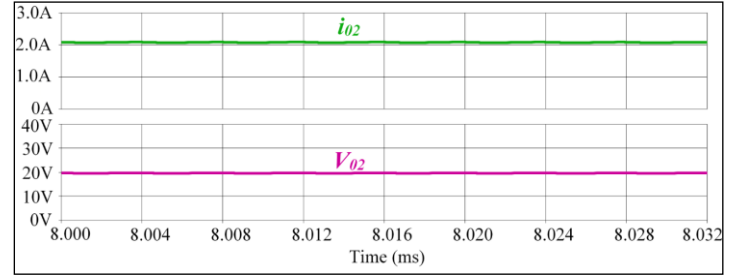


(c)

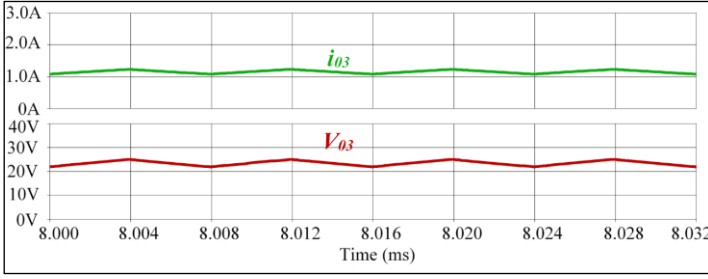
Figure 6: (a) Gate voltages of switches  $M_1 - M_4$  (b) Output voltages of half bridge inverters resonant currents and input voltages of diode bridge rectifiers.  
Source: Authors, (2026).



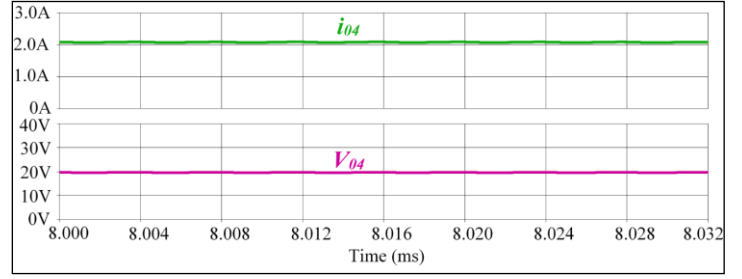
(a)



(b)

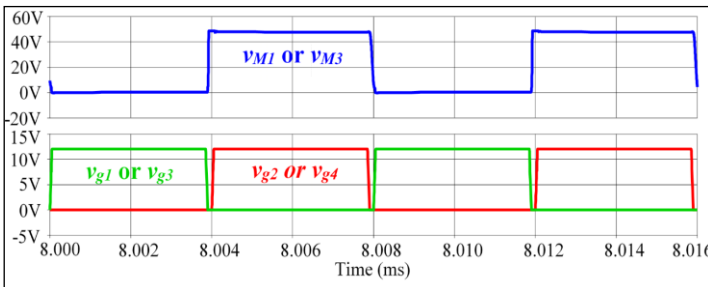


(c)

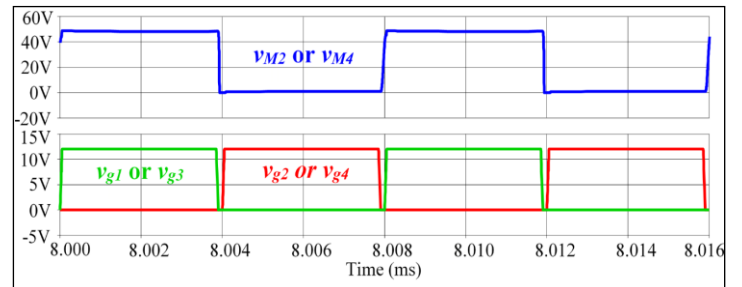


(d)

Figure 7: Simulated voltage and current waveforms in all LED lamps (a) LED lamp-1 (b) LED lamp-2 (c) LED lamp-3 (d) LED lamp-4.  
Source: Authors, (2026).



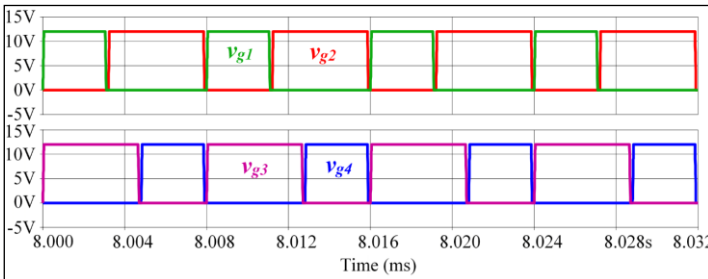
(a) Voltage and current in switch  $M_1$  and  $M_3$ .



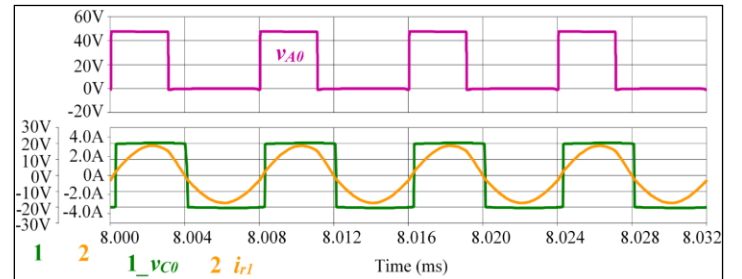
(b) Voltage and current in switch  $M_2$  and  $M_4$ .

Figure 8: (a) and (b) Switching waveforms of all devices.

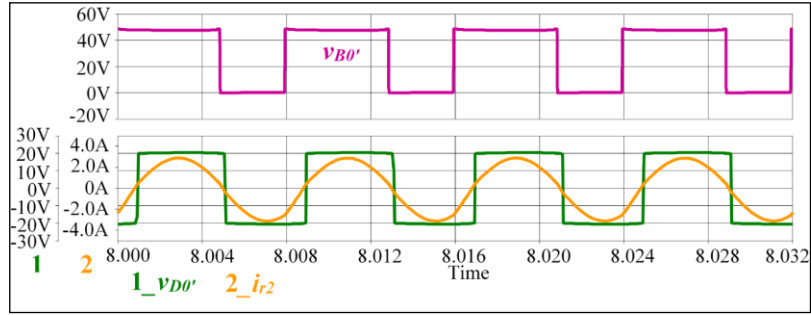
Source: Authors, (2026).



(a)



(b)



(c)

Figure 9: Simulation results at  $D_1 = 0.4$  and  $D_3 = 0.6$ . (a) Gate voltages of switches  $M_1 - M_4$  (b)  $v_{A0}i_{r1}$  and  $v_{C0}$  (c)  $v_{B0'}$ ,  $i_{r2}$  and  $v_{D0'}$ .  
Source: Authors, (2026).

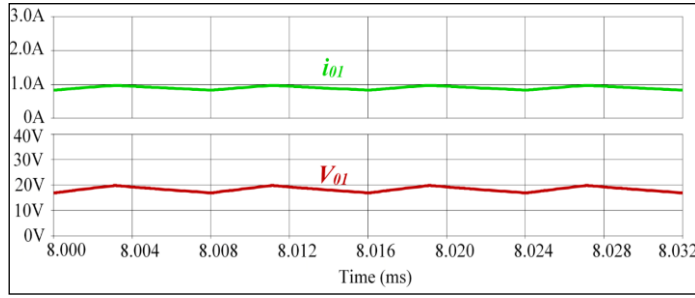
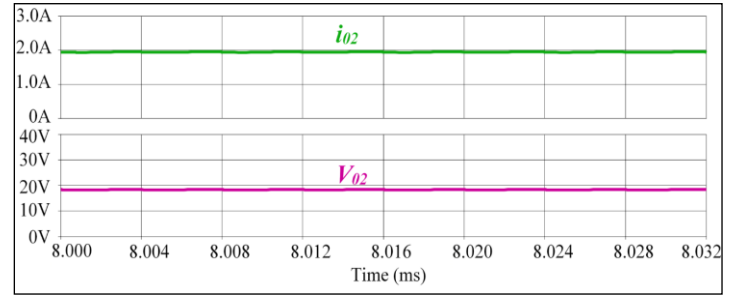
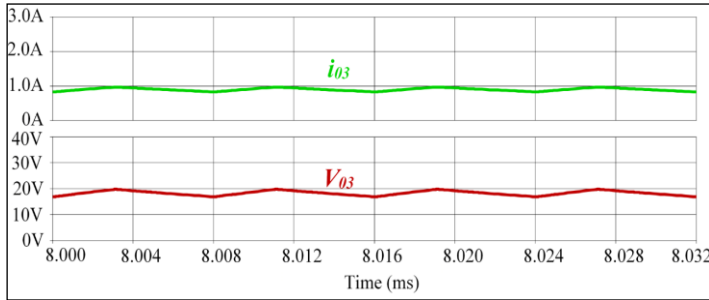
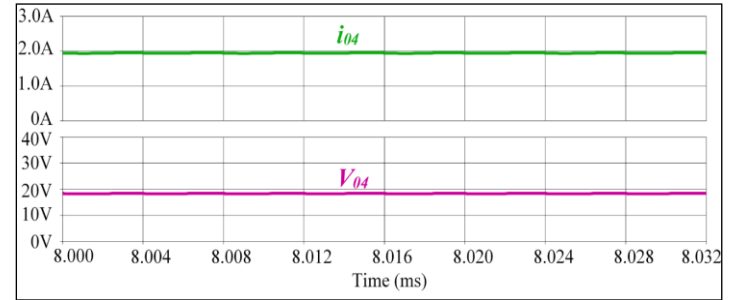

(a)  $V_{01}$  and  $i_{01}$ .

(b)  $V_{02}$  and  $i_{02}$ 

(c)  $V_{03}$  and  $i_{03}$ 

(d)  $V_{04}$  and  $i_{04}$ 

Figure 10: Simulated voltage and current waveforms in all LED lamps at  $D_1 = 0.4$  and  $D_3 = 0.6$ .  
Source: Authors, (2026).

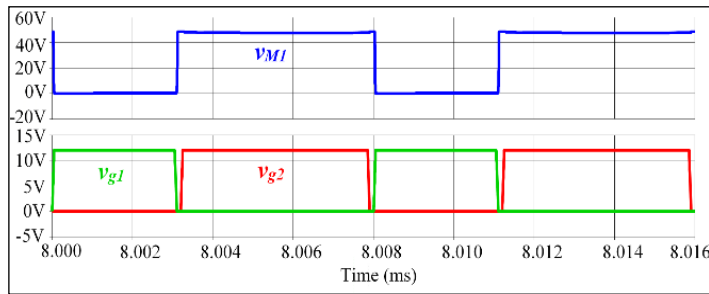
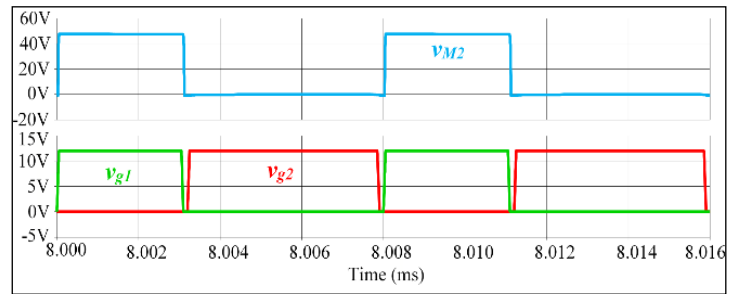
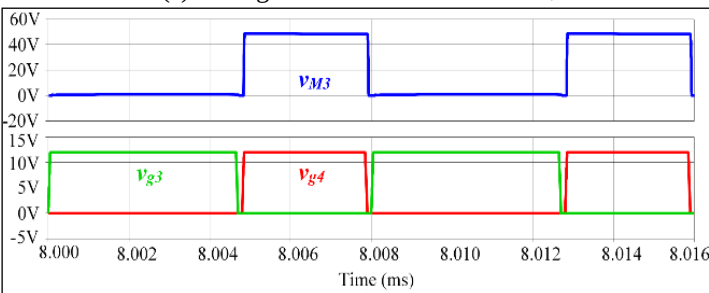
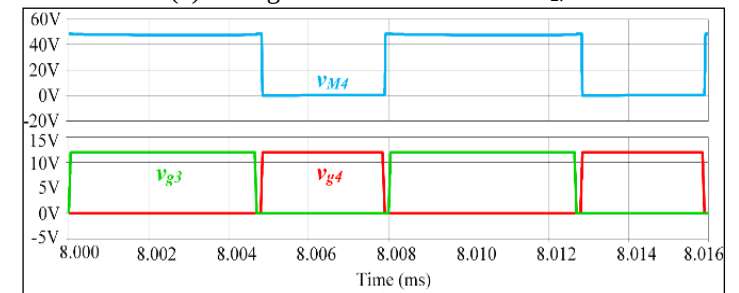

(a) Voltage and current in switch  $M_1$ .

(b) Voltage and current in switch  $M_2$ .

(c) Voltage and current in switch  $M_3$ .

(d) Voltage and current in switch  $M_4$ .

Figure 11: Simulating waveforms of all devices at  $D_1 = 0.4$  and  $D_3 = 0.6$ .  
Source: Authors, (2026).

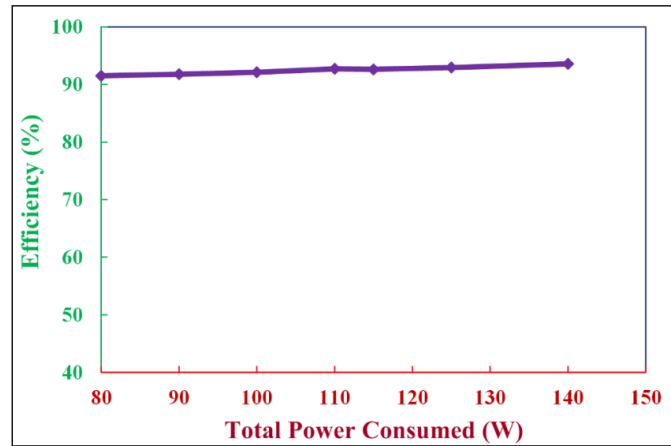


Figure 12: Efficiency curve at different power levels.  
Source: Authors, (2026).

## VII. CONCLUSIONS

This research paper introduces a novel buck integrated half based resonant LED driver configuration to power multiple LED lighting loads. A thorough analysis of the steady-state behavior is included to offer a detailed understanding of the circuit's operation. To confirm the proposed design, extensive simulation results are presented.

The primary characteristics of the suggested LED driver are as follows:

1. Zero-voltage switching operation
2. Ability to power multiple lighting loads.
3. High efficiency
4. Independent power control
5. Regulation of lamp current via asymmetric duty ratio control
6. Minimal output ripple current

## VIII. AUTHOR CONTRIBUTIONS

**Conceptualization:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Methodology:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Investigation:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Discussion of results:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Writing – Original Draft:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Writing – Review and Editing:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Resources:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Supervision:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

**Approval of the final text:** Sreenivasulu Meda, Narendra Rao R and Ramakrishna Busharaju.

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