

Hardware Implementation of Integrated-Topology of DC/DC converter for LED Driver

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ABSTRACT

It has been noticed that in commercial lighting, in terms of efficiency light-lamps based on light-emitting diodes(LEDs) are far better as compared to those where traditional lamps which are still in use in major underdeveloped and developing areas worldwide. The LED have numerous advantages such as high luminous efficiency, life span and it has no mercury in its composition. Therefore, recently researchers of this area has been setting a goal to utilize LED as a good alternative to save electricity from major parts of this planet.

In this paper hardware implementation of LED driver circuit is presented to utilize the 12 V LED lighting strip which has been used in Indian hawkers/small shopkeepers since a long time.

Key words: LED, Commercial lighting, Driver circuit, PFC, MATLAB/Simulink.

1. INTRODUCTION

There are more than 10 million Indian hawker/street vendors according to Ministry of Housing and Urban Poverty Alleviation [1], lighting is a major issue for them. Most of them are using 12 volt LED lights as they do not have the regular electrical supply. 12 volt LED is preferred as the 12 volt battery used in vehicles is easily available in the market. In the current scenario many researchers have been setting a goal to utilize LED lifespan with efficient and good driver circuit. Driver circuits provides the supply for the LED lamps, these circuits must be compatible enough so that they can convert electrical energy from the line and supply and process it with continuous current to the LED lights. Also, the driver lifespan and LEDs lifespan must be coherently maintained, so that lamps do not lose any of its main features, especially its own lifetime factor. W. Yang et al [2] presented a highly efficient multiple-output buck-type led driver which uses only single-inductor. Various buck converter based topology is

also found in literature [3, 4, 5, 6, 7, 8, 9]. Power factor improvement is the main concern of the researcher working in this area, some of the researcher suggested topologies with improved power factor [9, 10]. Electrolytic Capacitor-Free topology is also available in literature which improves the lifetime of the driver [11, 4, 12, 13, 10, 14, 15, 16]. Amongst the esteemed researcher Cassio Gobbato et al [17] presented Integrated Topology of DC/DC Converter for LED Street Lighting System. This topology has been simulated and presented in this paper for 12 Volt LED lights. Topology presented in [17] is implemented as it is but the design parameters has been modified in accordance with the Indian scenario [18,19,20].

2. TOPOLOGY IMPLEMENTED

In this paper the topology given in [17] is implemented and realized in hardware and the circuit diagram of this topology is given in Figure 1.

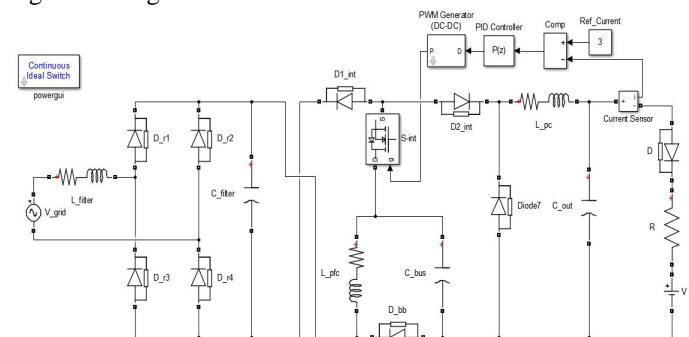


Figure 1: Circuit diagram of integrated DC/DC converters [17].

The electrical modeling of LED as shown in the Figure 2 is a series connection of an ideal diode (D), a resistor (R) and a voltage source (V). Voltage source characterizes the minimum voltage required to make LED forward biased.

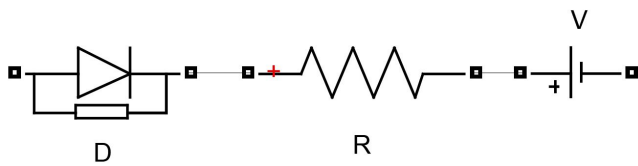


Figure 2: Electrical modeling of LED in MATLAB Simulink

Integrated topology [17- 18]: Quanming Luo et al [18] present Single-Stage AC-DC LED Driver which is integration of two DC/DC converters. First power factor correction (PFC) unit which is Buck-Boost converter operating in discontinuous conduction mode (DCM) and second is an isolated DC/DC unit with a voltage rectifier. This integration is possible by sharing the same power switch and both the converters must operate in same duty ratio and same switching frequency.

T-type inverted presented in [17] and [18] shown in Figure 1 is the series connection of buck-boost and buck converters shown in Figure 3 and Figure 4. In this topology the drains of the switches S_{bb} and S_b share the same node thus replacing the S_{bb} and S_b switches by S_{int} switch and adding two diodes D_{int} and D_{2int} as shown in Figure 1.

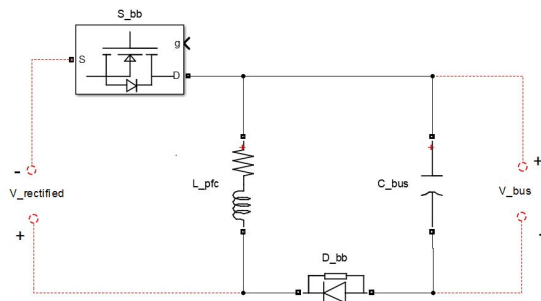


Figure 3: Buck-boost converter

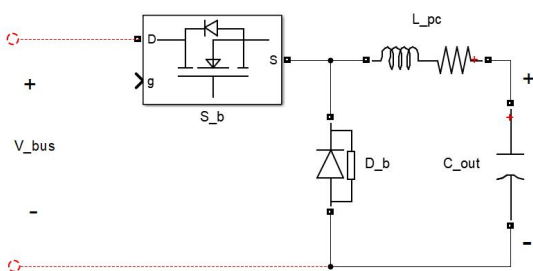


Figure 4: Buck converter

3. DESIGN PARAMETERS

Design parameters used in the base paper [17] is shown in table 1 below:

Table 1: Design parameters used in [17]

Symbol	Specification	Value
V_{GRID}	Mains voltage (RMS)	127V
f_r	Mains frequency	60Hz
P_o	Output power (each module)	25W
I_{leds}	Average Output current	500mA
V_{bus}	Average PFC output voltage	170V
V_{out}	Average PC output voltage	51V
ΔI_{leds}	LEDs current ripple	100mA - 20%
ΔV_{bus}	PFC output voltage ripple	85V - 50%
ΔV_{out}	PC output voltage ripple	1.02V - 2%
f_s	Switching frequency	60 kHz

Design parameters shown in table 1 are modified according to Indian hawkers/street vendors lighting requirements. As discussed in the introduction section Indian hawkers already using 12 V LED lights which are directly connected to a 12 V battery. The LED driver presented in this paper also uses 12 V output to fulfill the hawkers lighting demand. The LED strip or light can be used directly with 12V battery when grid is unavailable and once the grid is available one can use this driver to light the same LED. The modified design parameters used in this paper is shown in table 2.

Table 2: Design parameters used in this paper

Symbol	Specification	Value
V_{GRID}	Mains voltage (RMS)	170V
f_r	Mains frequency	50Hz
P_o	Output power (each module)	25W
I_{leds}	Average Output current	2.2A
V_{bus}	Average PFC output voltage	85V
V_{out}	Average PC output voltage	10V
ΔI_{leds}	LEDs current ripple	100mA - 20%
ΔV_{bus}	PFC output voltage ripple	85.6 to 87.6V (2.35%)
ΔV_{out}	PC output voltage ripple	12.356 to 12.346 - (0.08%)
f_s	Switching frequency	60 kHz

4. HARDWARE IMPLEMENTATION AND RESULTS

Hardware implementation of the integrated topology is presented in Figure 5; results are discussed in this section. Control signal is generated through the Arduino UNO and air core inductors are used. Supply is given through variac for regulation. Ammeter, voltmeter, multimeter and DSO are used for various measurement.

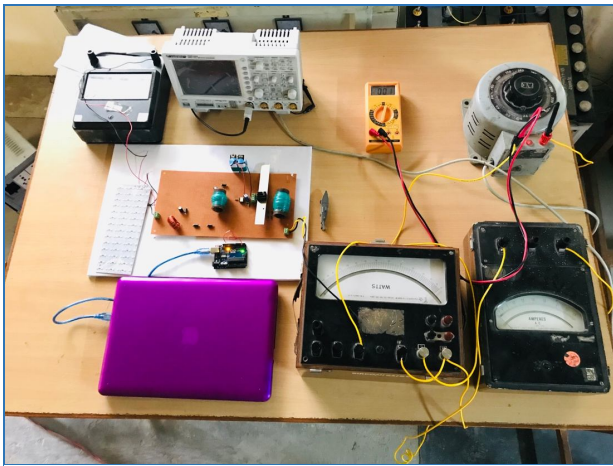


Figure 5: Hardware implementation of integrated topology.

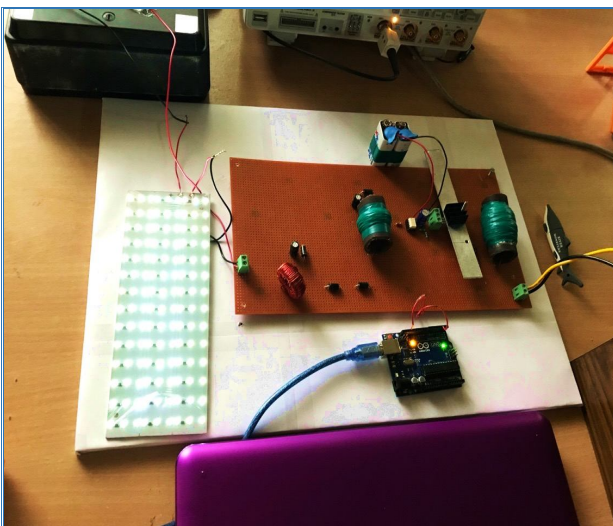


Figure 6: Complete functioning setup of integrated topology.

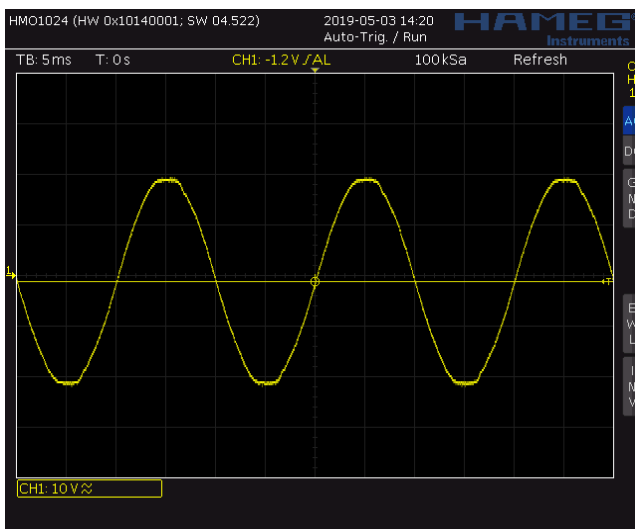


Figure 7: Input voltage waveforms without harmonics (LED module not connected), voltage 10V/div probe setting 10x, peak value of voltage = 240V.

Figure 7 shows the input voltage waveform the result obtained in HAMEG digital signal oscilloscope (DSO) the supply is given through the variac. In the base paper [17] the RMS value of given voltage is 127V RMS but in this paper we have used 170 V RMS as a input. For input 170V the output we get is about 8V DC the design is further tested for 230V AC mains which can give upto 12V DC output for proper illumination.

Figure 8 shows the ripple in the input voltage which is less than 1% hence the minimum flickering occurs in the LED light.

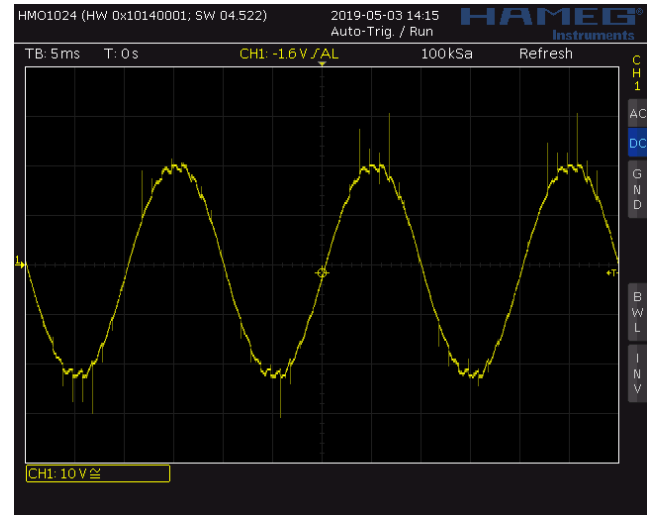


Figure 8: Input voltage waveforms with harmonics (LED module connected), voltage 10V/div probe setting 10x, peak value of voltage = 230V.

Figure 9 shows the output voltage at the LED end which is 8 volt.

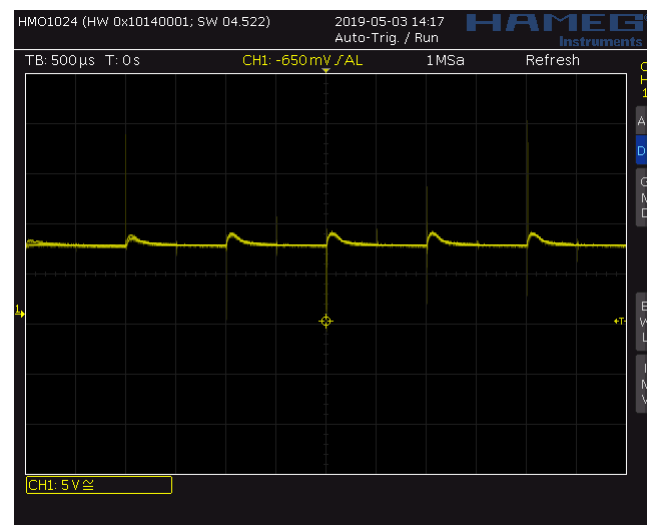


Figure 9: Output voltage waveforms at LED, voltage 5V/div probe setting 1x, peak value of voltage = 8V.

5. CONCLUSION

In this paper integrated topology of DC/DC converter is presented for LED driver circuit, this topology has been presented by Cassio Gobbato et al however the designed parameters have been changed in accordance with the Indian hawker/street vendors. About 10 million Indian hawker/street vendors in India having irregular power supply. The topology is modified in accordance with them and the output voltage is stabled at 8 Volt DC which can fulfill their lighting needs with less than 1 % ripples in the output.

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