DESIGN AND ANALYSIS OF LUO CONVERTER BASED LED DRIVER

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Abstract: **Light-emitting diodes (LEDs) have become increasingly popular as solid-state lighting sources nowadays. DC-DC conversion has greater importance in LED driver circuit. DC-DC conversion can be reliably performed using LUO converter. It employs voltage lift technique so that output voltage is increased stage by stage. The LED driver could achieve nearly a unit power factor by operating the LUO circuit at discontinuous conduction mode. The voltage lift technique is a popular method that is widely applied in electronic circuit design. This technique gives a good way is improving circuit characteristic and has been successfully applied for DC-DC converter. LUO converters are DC-DC step-up converter using only one switch. The major benefits of this proposed scheme is that it combines the advantages of the switched capacitor, voltage lift technique and the impedance network. MATLAB Simulink has been used to show existing and proposed system results.**

Keywords: **LUO converter, Voltage lift, Arduino Nano, UART.**

I. INTRODUCTION

The advantages of superior longevity, fast response, small size, and colour rendering, light-emitting diodes (LEDs) have been widely used for various lighting applications, such as signage lights, traffic lights, liquid crystal display television, back lights etc. Since the package and costing technology are getting more and more mature, the cost of LEDs decreases greatly, with a great potential to replace existing lighting sources such as fluorescent lamps. Since the encapsulation technology of LEDs has become mature in the recent years the LEDs are applied to the lighting areas such as the LCD backlight, the street lighting and the car head lighting. Generally, the use of LEDs is the development direction of the future lighting system. If neglecting the affection of the junction temperature, the illumination of the LEDs is in proportion to its average current, so the LEDs need constant current control. The luminance of a single LED is very low, so the LEDs are usually used in series. While if all LEDs are connected in series, the whole system will stop working if one of the LEDs is broken, so the LED arrays are always with parallel connection. Traditional LED driver is consists of three parts, which is the power factor correction (PFC) circuit, the DC/DC voltage regulate circuit and the constant current Circuit.

Conversion technique is one of the major research area in the field of power electronics .The equipment used for conversion technique are found to have applications in industry, research and development, various organizations and in daily life. All the existing DC/DC converters are designed to meet the requirements of certain applications only. The conventional types of DC/DC converters include Buck converter, Boost converter, Buck-Boost converter, CUK converter etc. Among these, boost converter is found to be applicable in large number of applications like, Hybrid Electric Vehicles (HEV), lighting systems, tramways, railway electrification. The DC/DC conversion technique was established in 1920s.The simplest form of conversion was using voltage divider. Now various advanced methods are available for DC/DC conversion. It ranges from voltage lift technique to super lift and ultra-lift technique.

II. OPERATIONAL PRINCIPLE OF THE PROPOSED LUO CONVERTER

Voltage Lift (VL) technique is a popular method widely used in electronic circuit design. It has been successfully employed in dc/dc converter applications in recent years, and opened a way to design high voltage gain converters. Four series LUO converters are the examples of VL technique implementations. However, the output voltage increases in stage by stage just along the arithmetic progression. This paper introduces a novel approach-super-lift (SL) technique that implements the output voltage increasing in stage by stage along the geometric progression. It effectively enhances the voltage transfer gain in power series.

In order to sort these converters different from existing VL converters, we name these converters "positive output super-lift converters." There are two subseries: main series and additional series. Each circuit of the main series has one switch S, n inductors, 2n capacitors, and (3n-1) diodes. Each circuits of the additional series has one switch S, n inductors, (2n+1) capacitors and (3n+1) diodes. The conduction duty radio is K, switching frequency is f (period T=1/f), the load is resistive load R. The input voltage and current Vin and Iin, output voltage and current Vo and Io. Assume no power losses during the conversion process Vin*Iin=Vo*Io. The voltage transfer gain is G:G=Vo/Vin.

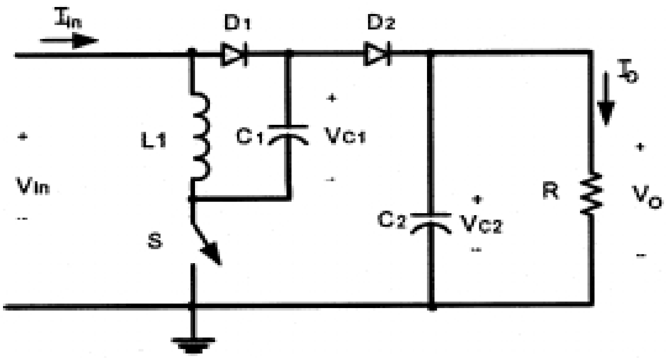

Fig 1: LUO converter

A. Operation:

The circuit and its equivalent circuit during switching-ON and switching –OFF are shown in figure. The voltage across the capacitor C1 is charged to Vin. The current iL1 flowing through inductor L1 increases with voltage Vin during switching-ON period kT and decrease with voltage (Vo-2Vin) during switching-OFF period (1-k)T. Therefore, the ripple of the inductor current iL1.

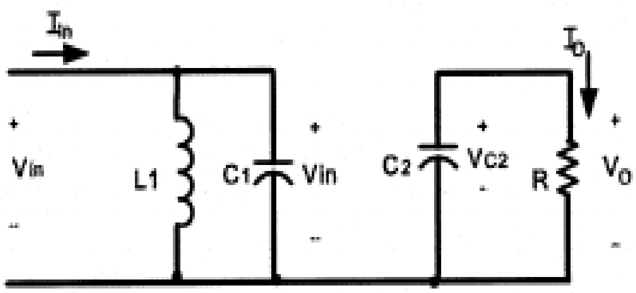

Fig 2: LUO converter ON state

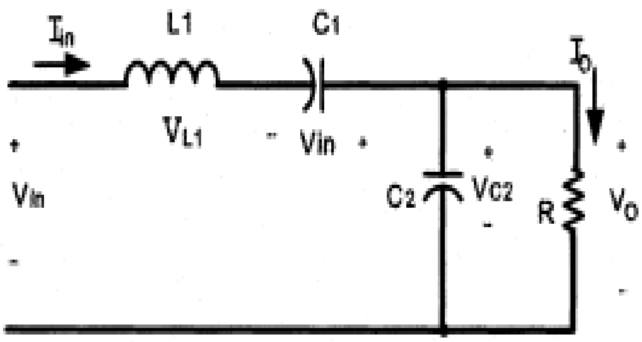

Fig 3: LUO converter OFF state

$$\Delta i_{L1} = \frac{V_{in}}{L_1} kT = \frac{V_O - 2V_{in}}{L_1}(1-k)T$$

$$V_O = \frac{2-k}{1-k} V_{in}.$$

The voltage transfer gain is

$$G = \frac{V_O}{V_{in}} = \frac{2-k}{1-k}.$$

$$G = \frac{V_O}{V_{in}} = \frac{2-k}{1-k}.$$

The input current i_{in} is equal to(i_{L1}+i_{C1}) during switching-on, and only equal to i_{L1} during switching-off. Capacitor current i_{C1} is equal to i_{L1} during switching-off. In steady-state, the average charge across capacitor C1 should no change.

B. Luo converter tranfer function:

- To analyze the stability and control loop behaviour
- To visualize the influence of supply voltage or load changes
- To minimize the influences of supply voltage variations and load changes on the output voltage of a DC/DC converter loop, compensation designs are necessary. The quality of this control circuit design defines the stability of the entire

C. ***Dc/dc converter:***

- Aloopisstablewhenitsphasereaches-180°after the gain has dropped below 1 (= 0dB). If this condition is not fulfilled a frequency exists at which the gain is higher than 1 and the phase shift is exactly 180$^{o.}$
- The impedance measurement could help evaluate possibility of DC/DC converter front –end oscillation.
- The duty cycle to output transfer function carries the information needed to determine the structure of voltage feed –back compensation.
- Input to output transfer function is necessary to analyze the audio susceptibility.

III. OPERATION OF PROPOSED LUO CONVERTER

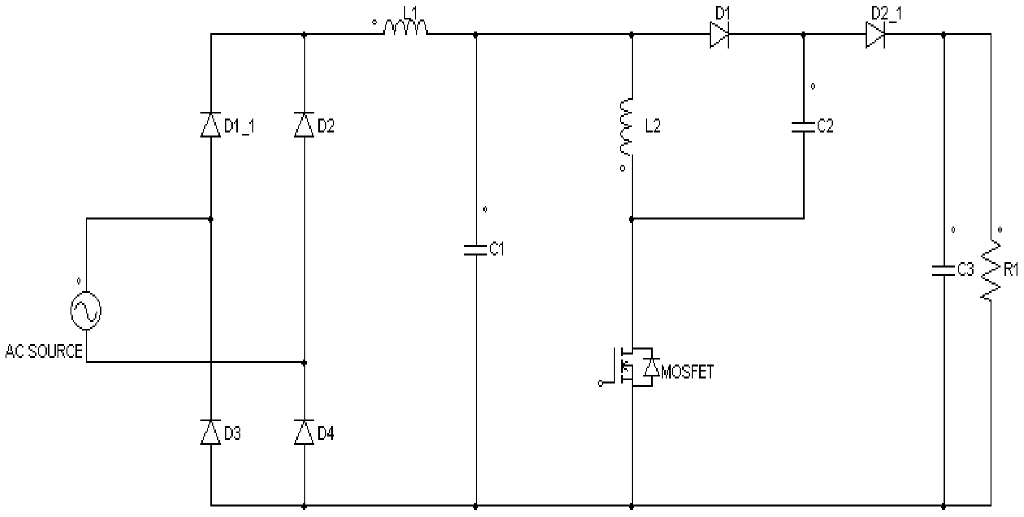

Fig 4: Proposed LUO converter

The proposed system consists of a diode bridge rectifier at the input stage and LUO converter at the regulating stage. The AC input available at the household socket is converted into DC by the diode bridge rectifier. The output of bridge rectifier is then filtered DC output serves as input to the LUO converter, the LUO converter is controlled by a closed loop feedback system, which generates firing pulses for the power electronic switch in the converter. The control circuitry uses PWM technique to produce the firing pulses. The duty cycle of the LUO converter is varied according to the output voltage hence regulation of the voltage is achieve. The output of LUO converter is again filtered using an (L-C) filter. The required voltage rating of the LUO is given as reference to the control system which is continuously compared with LUO converter output for voltage regulation.

IV. CONTROLLER OF PROPOSED SYSTEM

The proposed system is controlled by arduino nano controller and electronics communication are discussed as follows:

A. Ardunio controller:

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.

B. Power:

The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

C. Memory:

The ATmega328 has 32 KB, (also with 2 KB used for the boot loader. The ATmega328 has 2 KB of SRAM and 1 KB of EEPROM**.**

D. Communication:

The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. To use the SPI communication, please see ATmega328 datasheet.

TABLE I: TECHNICAL SPECIFICATIONS OF ARDUINO NANO

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by boot loader
SRAM	2 KB
Clock Speed	16 MHz
Analog I/O Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12 V
Digital I/O Pins	22
PWM Output	6
Power Consumption	19 Ma
PCB Size	18 x 45 mm
Weight	7 g
Product Code	A000005

V. SIMULATION RESULT ANDANALYSIS

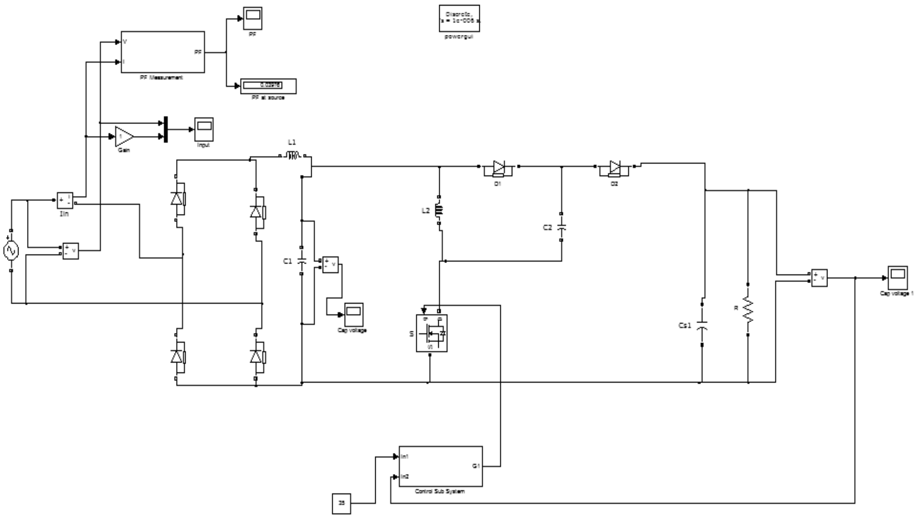

Fig 5: Simulation circuit in MATLAB for the proposed system.

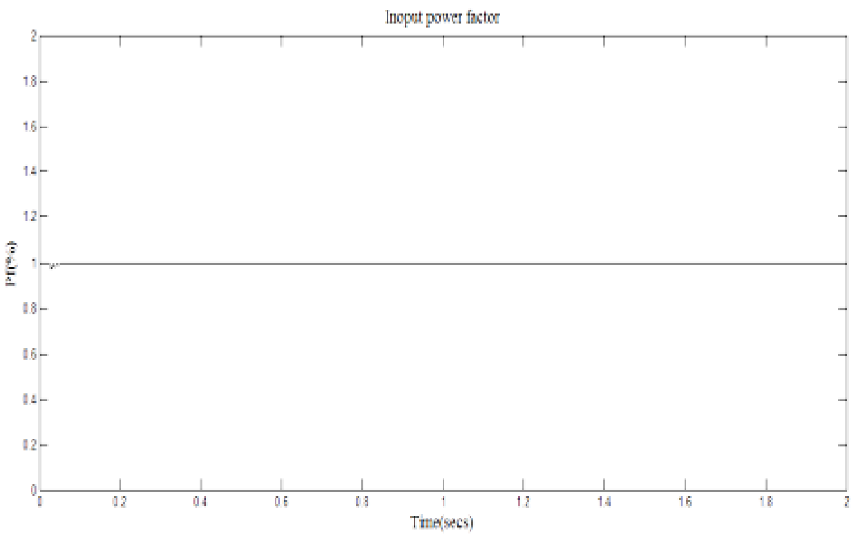

Fig 6: Shows the power factor for the proposed LUO converter which almost maintained unity from the beginning without many deviations.

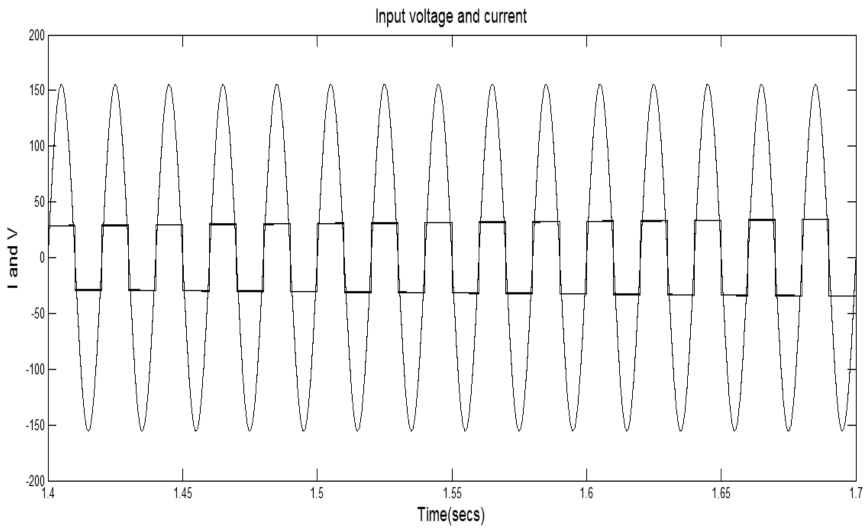

Fig 7: Input voltage and current waveform for proposed System

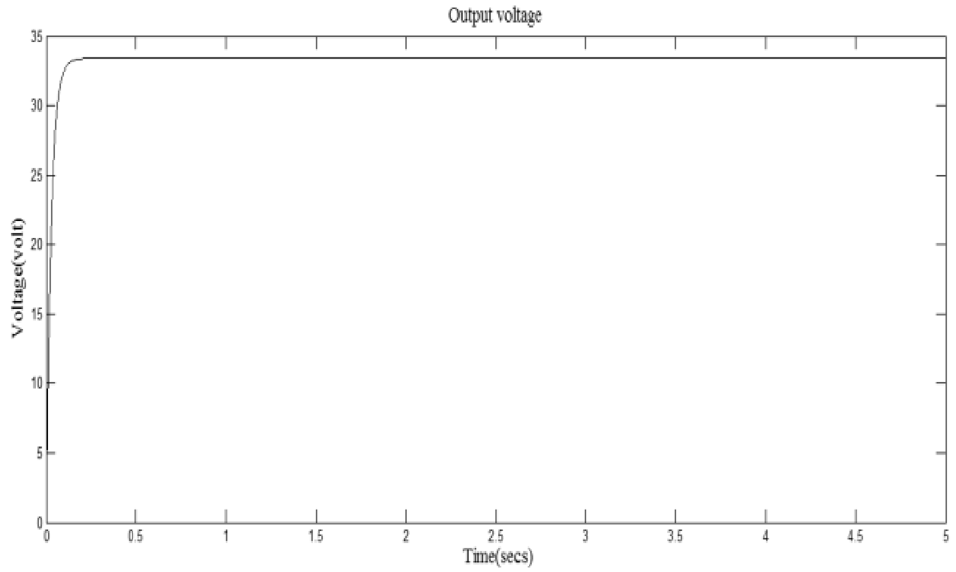

Fig 8: simulated output voltage waveform for proposed system

The input current and voltage waveform of the proposed LUO converter is shown in Fig. The voltage and current are almost pure sinusoidal in nature thus having low THD value. Shows that voltage is maintained constant at the required output voltage level in accordance with rating of LEDs used.

VI. HARDWARE IMPLEMENTATION

The hardware consists of driver circuit, ARDUINO controller, LUO converter and the impedance network. Here the switches in luo converter are realized by using the MOSFET. The 230V AC is step–down to 12V using a step down transformer. As the step down AC is to be given to the driver circuit and the ARDUINO controller, a multi-taping transformer is used. The driver circuit provides the desired PWM switching pulse for the MOSFET to operate. The final output at the load side can be measured using multi meter. The figure shows input and output waveform for the proposed converter which is a DC waveform with minimal ripple content. The gate source voltage of the MOSFET is also shown in the figure which is a pulsed DC waveform which is the switching signal applied to the MOSFET.

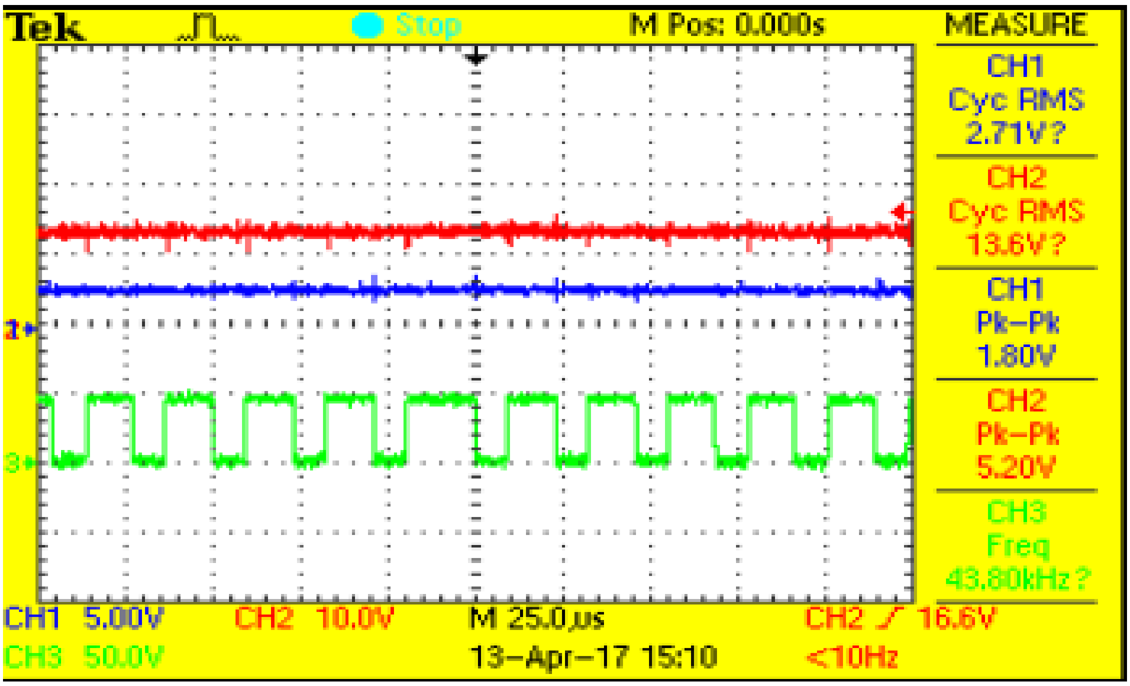

Fig 9: output voltage waveform

TABLE II: PARAMETERS OF THE PROPOSED AC/DC CONVERTER

Components	Value	Model
Diodes		
MOSFET		IRF950N
C1	0.47uf	
C2	2uf	
C3	2uf	
L1	3mH	
L2	10mH	
Transformer	460uH, n_p=24, n=7	

VII. CONCLUSION

This project presents a Design of LUO converter based on LED driver. With careful components parameters design, the proposed converter can achieve soft-switching characteristics, which highly reduce switching losses and improve the system efficiency. In the current study, the proposed developed LUO converter has been shown to be capable of providing a topology that reduces the output ripple and losses .Simulation results verified the design and calculations.

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