# SIMULATION OF A DC-DC CONVERTER FOR SOLAR LED STREET LIGHTING

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*Abstract:* The renewable energy sources are solar, wind and fuel cells. Solar energy can be converted to energy and used to many applications such as heat water for use in homes, buildings and that inside greenhouses, homes. Fuel cell: A fuel cell is an electrochemical conversion device that converters hydrogen and oxygen into electricity, heat and water. Demerits: In the past fuel cell were large and extremely expensive to manufacture. Since the fossil fuels are reduces gradually and the usage of fossil fuels results in the greenhouse effect and environmental pollution. Wind energy: wind turbines have its own impact on wildlife and surrounding environmental. It produces noise disturbances, threat to wildlife, suited to particular region. Due to the drawbacks of wind and fuel-cell we select the solar energy. Solar radiation is observed by PV cells (or) a solar cell which is used to charge the solar radiation into direct electricity. This electricity gives to the DC-DC converters.

In previous days this solar LED street lighting required two converters. One converter is used for battery charging in day time. Another one contactor is used for supply the LED street lighting from battery at night time. In this process switching losses are taking place and taking place and the cost of two contactors are also high. By avoiding these drawbacks we used to implement the using of single DC-DC converter instead of two converters. The application of solar powered LED street lighting.LED lighting offers high efficiency, long operating life and low voltage operation which ideal for solar. Solar street lights were initially used in remote locations and disaster prone areas.

***Index Terms* - Light emitting diodes, Batteries, Lighting, Switches, Inductors, Next generation networking, DC-DC power converters**

## I. INTRODUCTION

Recently light-emitting diodes (LEDs) are becoming increasingly attractive lighting sources in our daily lives. They are well suited to indoor and outdoor energy-saving lighting applications, such as general lighting, architectural lighting, traffic lighting, background lighting, displays, street lighting, automotive and motorcycle lighting, decorative lighting, and so on. The placement of street lights is closely related to the development of one area or region, and they represent the financial success of a city. For street lighting applications, the traditional lighting sources are high-pressure sodium lamps and high-pressure mercury lamps Recently, LEDs are commonly being used as new sources for street lighting because of their attractive features of good lighting efficacy, energy-savings, that they are non-polluting to our environment, and that they offer a long lifetime in comparison to their traditional counterparts.

An LED street light is an integrated light that uses light emitting diodes (LED) as its light source. These are considered integrated lights because, in most cases, the luminaries and the fixture are not separate parts (except LED Gene-based luminaries). New in manufacturing, the LED light cluster is sealed on a panel and then assembled to the LED panel with a heat sink to become an integrated lighting fixture. Different designs have been created that incorporate various types of LEDs into a light fixture. The current trend is to use high power 1 watt LEDs. However, some companies use low power LEDs in their products, including several low power LEDs packed together to perform the same purpose as a single high power LED. The shape of the LED Street light depends on several factors, including LED configuration, the heat sink used with the LEDs and aesthetic design preference. Heat sinks for LED street lights are similar in design to heat sinks used to cool other electronics such as computers. Heat sinks tend to have as many grooves as possible to facilitate the flow of hot air away from the LEDs. The area of heat exchange directly affects the lifespan of the LED Street light.

The lifespan of an LED street light is determined by its light output compared to its original design specification. Once its brightness decreases by 30 percent, an LED street light is considered to be at the end of its life. The LED driver combines a dual boost PFC AC-DC converter with a half-bridge-type LLC DC-DC resonant converter into one power conversion stage.

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## II.SOLAR ENENRGY:

A photovoltaic system is based on the ability of certain materials to convert the radiant energy of the sun into electrical energy. The total amount of solar energy that lights a given area is known as irradiance (G) and it is measured in watts per square meter ($W/m^2$). The instantaneous values are normally averaged over a period of time, so it is common to talk about total irradiance per hour, day or month. Of course, the precise amount of radiation that arrives at the surface of the Earth cannot be predicted with high precision, due to natural weather variations. Therefore it is necessary to work with statistical data based on the "solar history" of a particular place. This data is gathered by a weather station over a long period and is available from a number of sources, as tables or databases. In most cases, it can be difficult to find detailed information about a specific area, and you will need to work with approximate values.

A few organizations have produced maps that include average values of daily global irradiation for different regions. These values are known as peak sun hours or PSHs. You can use the PSH value for your region to simplify your calculations. One unit of "peak sun" corresponds to a radiation of 1000 Watts per square meter. If we find that certain area has 4 PSH in the worst of the months, it means that in that month we should not expect a daily irradiation bigger than 4000 $W/m^2$ (day). The peak sun hours are an easy way to represent the worst case average of irradiation per day. Low resolution PSH maps are available from a number of online sources, such as http://www.solar4power.com/solar-power-global-maps.html. For more detailed information, consult a local solar energy vendor or weather station.

Solar street lights are an efficient means to provide lighting with no utility lines. They provide cost savings by eliminating the need to trench wires and the recurring cost of power bills after installation. Solar street lights have been installed on highways, freeways, neighborhood streets, rural roads, etc. and provide security, sustainability and an overall green image. Every solar street light comes with a self-contained solar power assembly that is sized to run the fixture per the needs of the customer. Each power assembly is sized by the lamp power consumption times the number of hours of operation and how much sun is provided in each geographic area to provide adequate autonomy. The power assembly is mounted at the top of the pole, typically above the fixture(s). See our Solar Power Systems section for additional information and specifications.

Features Include:

- Self-contained solar power assembly comprised of single crystal solar modules bonded into a single array
- Full cover vented aluminum panel pan
- Welded rear channel mounting bracket
- Aluminum Vented battery storage console with sealed GEL batteries
- All control electronics
- Welded aluminum power bracket to bolt to any pole or wall

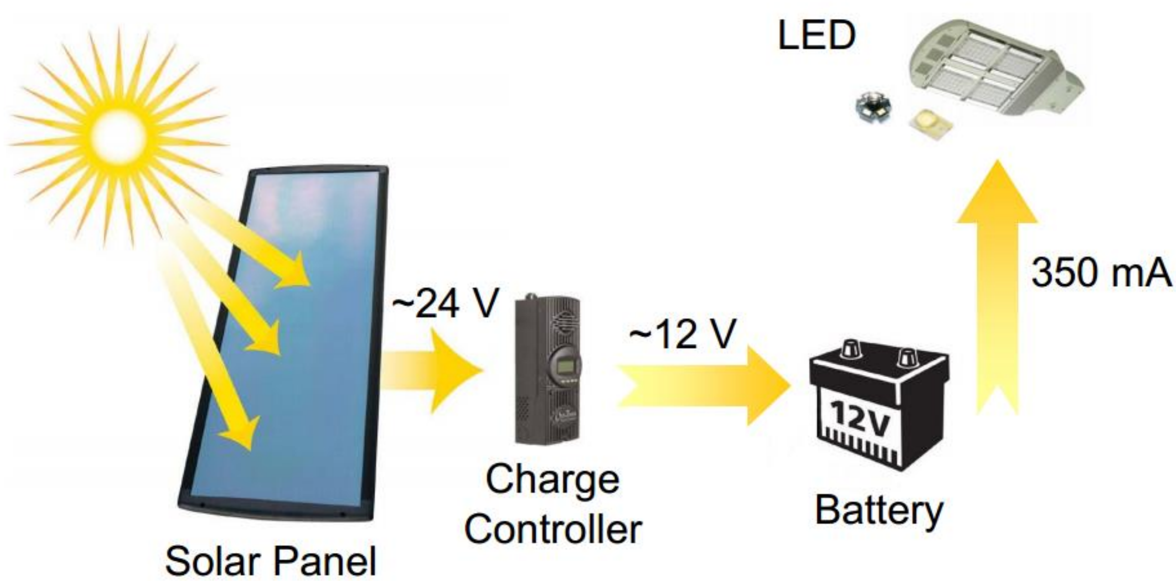



Fig 2.1 Block Diagram for Solar LED for Street Lighting

Fig 2.2 Solar LED for Street Light

Maximum Peak Power Tracking (MPPT)

- Solar panels in general are inefficient
- Charge controllers and other electronics need to be as efficiency as possible to maximize the benefits
- MPPT compensates for the changing Voltage versus Current characteristic of the solar cell to increase the efficiency

Solar Panel Characteristics:

Extracting the maximum amount of power from the solar panel is difficult due to the nonlinearity and variability of the Voltage-Current (V-I) characteristic.MPPT fools the panels into outputting a different voltage and current allowing more power to go into the battery by making the solar cell think the load is changing when you really are unable to change the load.

## III. DC-DC CONVERTERS

A DC–DC converter with a high step-up voltage gain is used for many applications, such as high-intensity discharge lamp ballasts for automobile headlamps, fuel cell energy conversion systems, solar-cell energy conversion systems and battery backup systems for uninterruptible power supplies. In general, a conventional boost converter can be adopted to provide a high step-up voltage gain with a large duty ratio. However, the conversion efficiency and the step-up voltage gain are limited due to the constraints of the losses of power switches and diodes, the equivalent series resistance of inductors and capacitors and the reverse recovery problem of diodes. However, the active switch of these converters will suffer very high voltage stress and high power dissipation due to the leakage inductance of the transformer. To reduce the Voltage spike, a resistor–capacitor–diode snubber can be employed to limit the voltage stress on the active switch. However, the efficiency will be reduced. High step-up converters with a low input current ripple based on the coupled inductor have been developed. The low input current ripple of these converters is realized by using an additional LC circuit with a coupled inductor.

However, leakage inductance issues that relate to the voltage spike and the efficiency remain significant. An integrated boost–fly back converter based on a coupled inductor with high efficiency and high step-up voltage gain has been presented. The energy stored in the leakage inductor is recycled into the output during the switch off period. Thus, the efficiency can be increased and the voltage stress on the active switch can be suppressed. Many step-up converters, which use an output voltage stacking to increase the voltage gain, are presented.

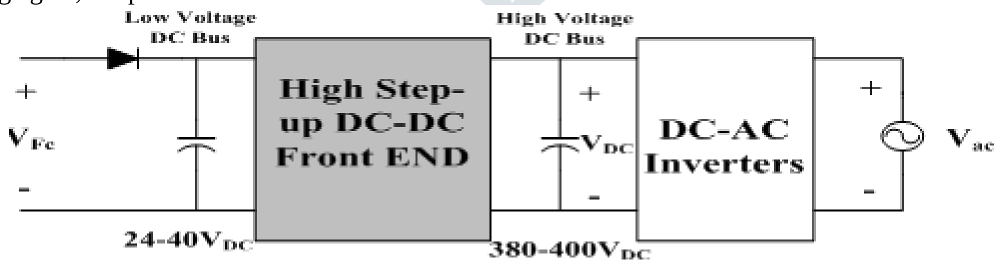



Fig.3.1. General Power generation system with a high step-up converter

A high step-up dc–dc converter is shown in Fig.3.1 with an integrated coupled inductor and a common mode electromagnetic interference reduction filter. Here a Sepic–fly back converter with a coupled inductor and an output voltage stacking is developed. A high step-up converter, which utilizes a coupled inductor and a voltage doublers technique on the output voltage stacking to achieve a high step-up voltage gain, is introduced. A high step-up boost converter that uses multiple coupled inductors for the output voltage stacking is proposed.

**3.1 PROPOSED CONCEPT INTRODUCTION:**

Since the fossil fuels are shortage gradually and the usage of the fossil fuels results in the greenhouse effect and environmental pollution, the energy saving and the development of renewable energy becomes more important. The renewable energies include solar power, wind power, ocean power, and hydrogen power. In the energy saving, the high performance lightings, including high intensity discharge (HID) and high brightness light emitting diode (LED) lamps, are developed rapidly. The conventional solar LED street lighting is shown in Fig. 3.1(a). The battery is charged from the solar module through the converter 1 in the day. Also, the energy stored in the battery is discharged to the LEDs through the converter 2. Therefore, two converters are required in this structure. Fig. 3.1(b) shows another structure for the solar LED street lighting. Only one converter is used in this structure. The DC-DC converter is shown in Fig. 3.3. The charging circuit is a DC-DC step-down converter and the discharging is a DC-DC step-up converter. The analysis is described in the following sections.

**3.2 CHARGING MODE:**

The equivalent circuit of the proposed converter in charging mode is shown in Fig. 3.4. The PWM technique is used to control the switch $S_1$. Fig. 3.5 shows some typical waveforms. The operating principle in continuous conduction mode (CCM) is described as follows:

(1) Mode 1, [$t_0$, t1]: The switch $S_1$ is turned on and switches, S2and S3, are turned off. The current flow path is shown in Fig. 3.6(a). The energy of the solar voltage source Vpv is transferred to the inductor $L_1$, the capacitor CB, and the battery.

(2) Mode 2, [t1, t2]: The switches $S_1$-$S_3$are turned off. The current flow path is shown in Fig. 3.6(b). The energy stored in the inductor L1is released to the capacitor CB and the battery.

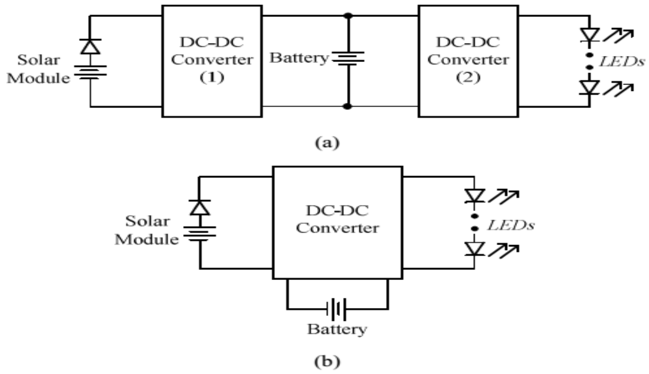



Fig.3.2. Structures of the solar LED street lighting.

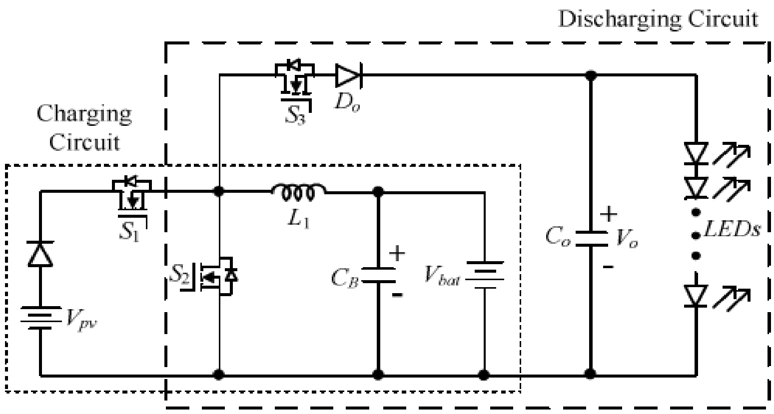



Fig.3.3.Circuit configuration of the proposed converter

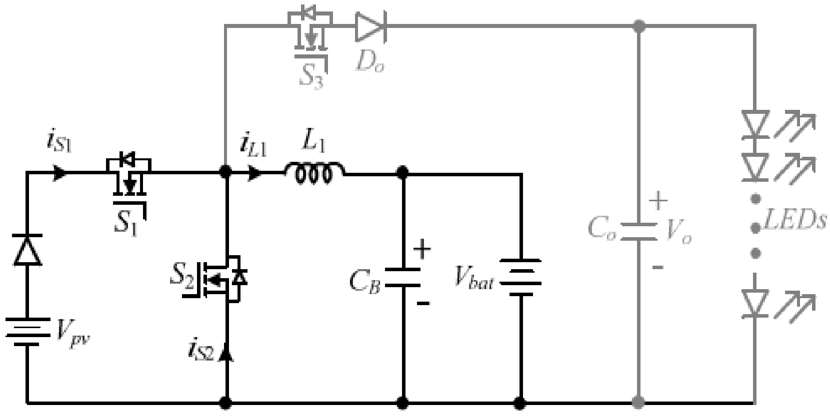



Fig.3.4.Equivalent circuit of the proposed converter in charging mode

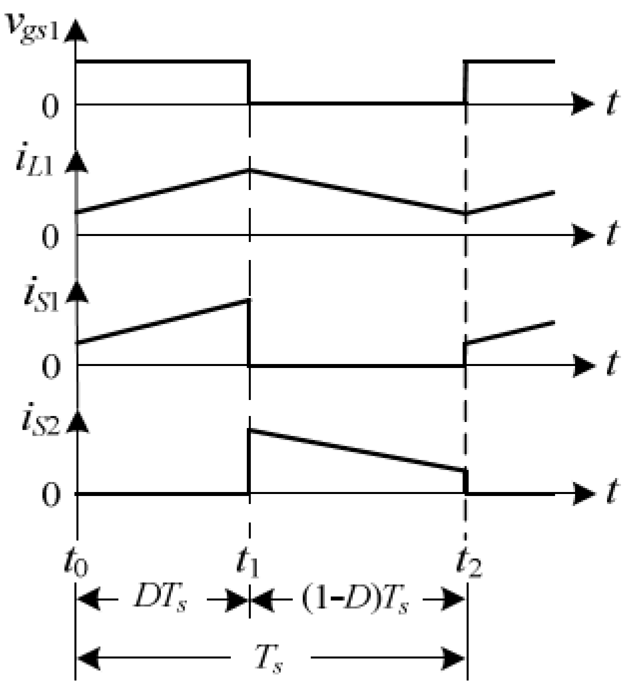
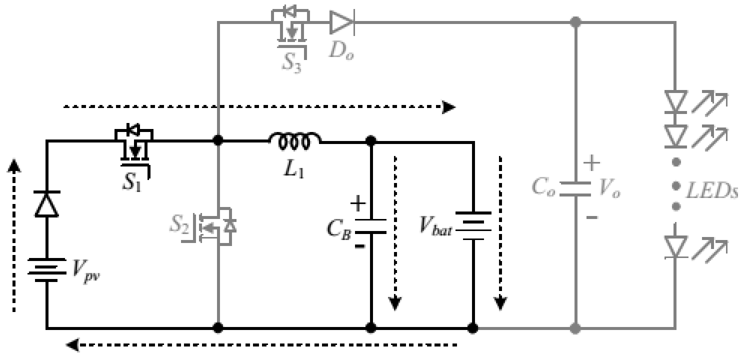
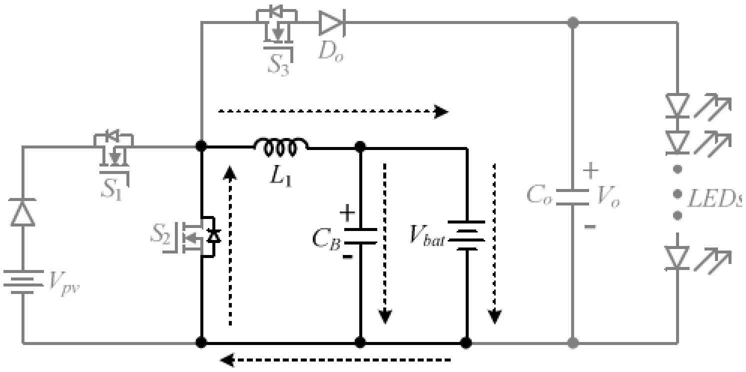



Fig.3.5.Some waveforms of the proposed converter in charging mode




(a) Mode 1




(b) Mode 2

Fig.3.6. Current flow path of the proposed converter in charging mode

By using the voltage-second balance principle, the voltage gain is obtained as

$$M_{ch} = \frac{V_{bat}}{V_{pv}} = D \quad \text{.............................} \quad (3.1)$$

Then, the inductor time constant is defined as

$$\tau_{ch} \equiv \frac{L_1}{R_B T_s} = \frac{L_1 f_s}{R_B} \quad \text{.............................} \quad (3.2)$$

Where$R_B$ is the equivalent load in the battery side. The boundary inductor time constant $\tau_{chB}$ is derived as follows:

$$\tau_{chB} = \frac{1-D}{2} \quad \text{..............................} \quad (3.3)$$

The curve of $\tau_{chB}$ is plotted in Fig. 3.6. If $\tau_{ch}$is larger than $\tau_{chB}$, the proposed converter in the charging mode is operated in CCM.

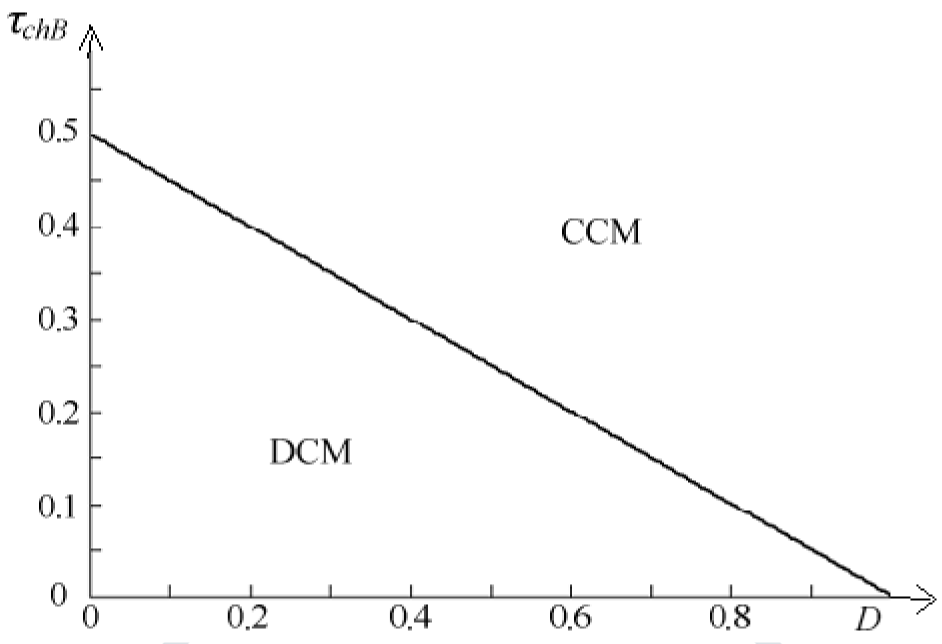



Fig.3.7.Boundary condition of the proposed converter in charging mode

### 3.3 DISCHARGING MODE:

The equivalent circuit of the proposed converter in discharging mode is shown in Fig. 3.8. The PWM technique is used to control the switches $S_2$ and $S_3$. Fig. 3.9 shows some typical waveforms. The operating principle in CCM is described as follows:

(1) Mode 1, [$t_0$, t1]: The switch $S_2$ is turned on and switches, $S_1$ and $S_3$, are turned off. The current flow path is shown in Fig. 3.10(a). The energy of the battery $V_{bat}$ is transferred to the inductor $L_1$. Also, the energy stored in the capacitor Co, is discharged to the LED.

(2) Mode 2, [$t_1$, t2]: The switch $S_3$ is turned on and switches, $S_1$and $S_2$, are turned off. The current flow path is shown in Fig. 3.10(b). The energies of the battery and the inductor L1are released to the capacitor Co and the LED.

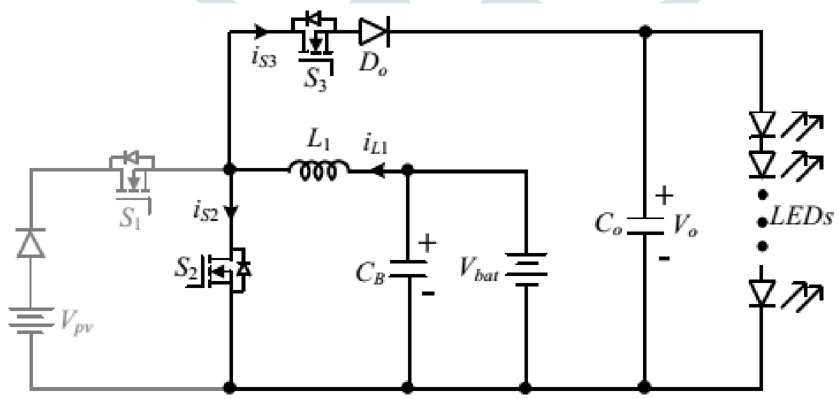



Fig. 3.8.Equivalent circuit of the proposed converter in discharging mode

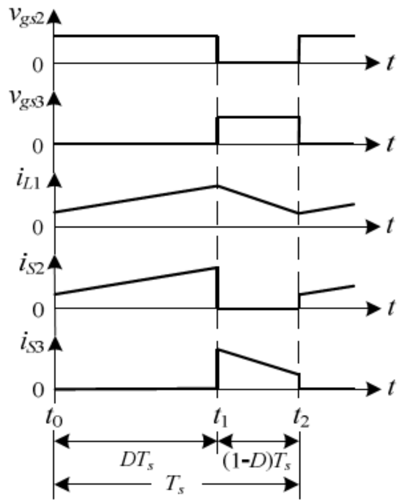



Fig.3.9.Some waveforms of the proposed converter in discharging mode.

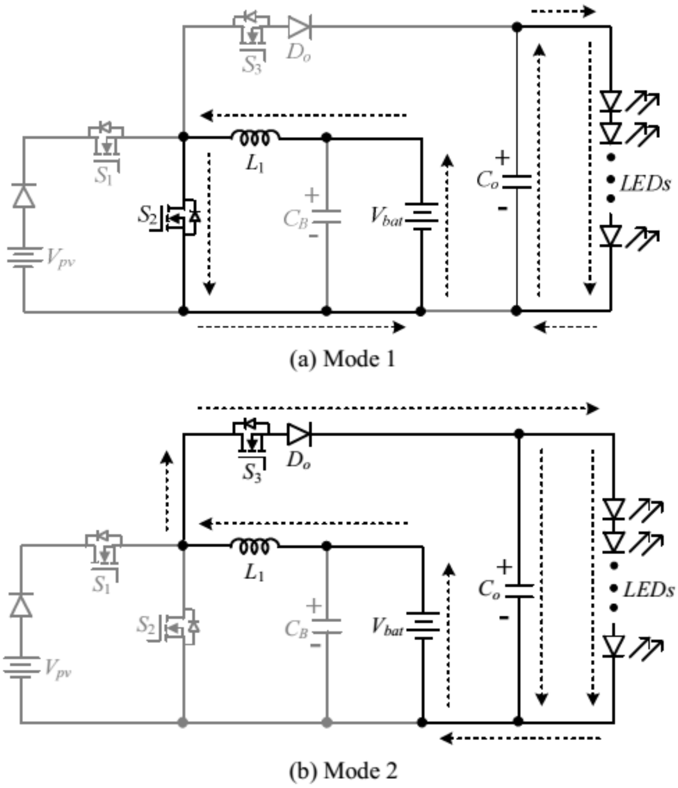



Fig. 3.10.Current flow path of the proposed converter in discharging mode

By using the voltage-second balance principle, the voltage gain is obtained as

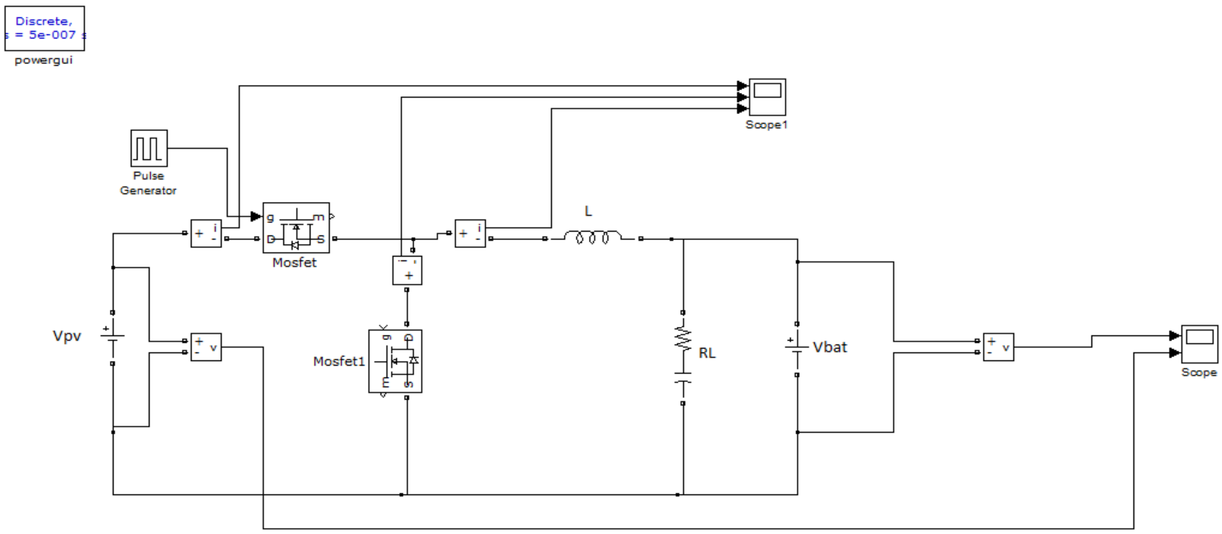
$$M_{dis} = \frac{V_o}{V_{bat}} = \frac{1}{1-D} \qquad \text{.........................} \quad (3.4)$$

$$\tau_{dis} \equiv \frac{L_1}{R_L T_s} = \frac{L_1 f_s}{R_L} \qquad \text{.........................} \quad (3.5)$$

$$\tau_{disB} = \frac{D(1-D)^2}{2} \qquad \text{.............................} \quad (3.6)$$

## IV. MATLAB/SIMULINK CIRCUIT & RESULTS:

### Charging mode:




**Simulation Results for the charging mode:**

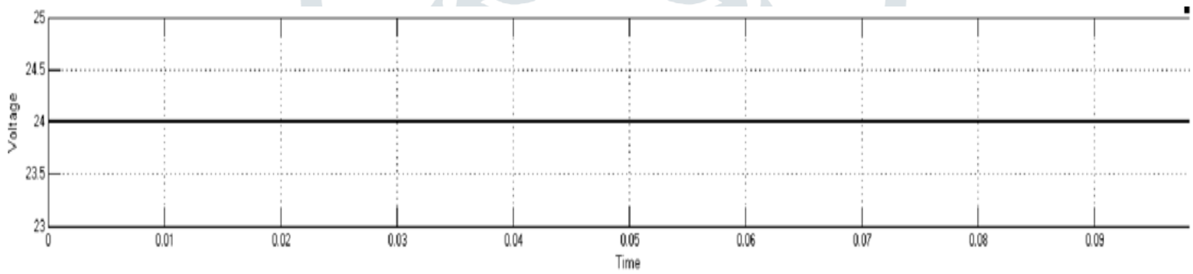



Fig 4.1(a) Input voltage to Buck converter

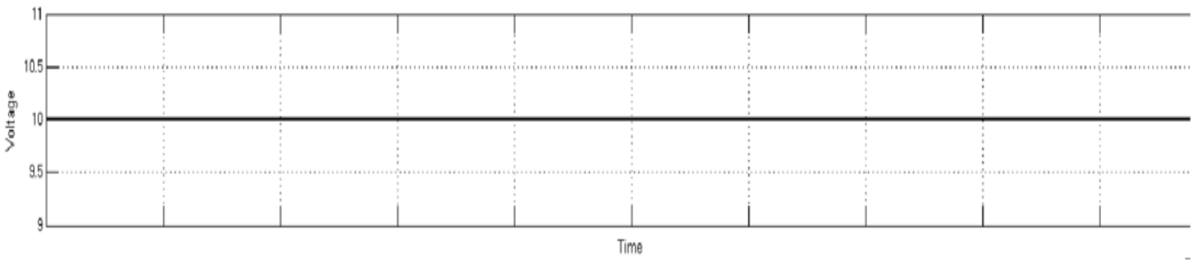



Fig 4.1(b) Battery voltage in Buck converter

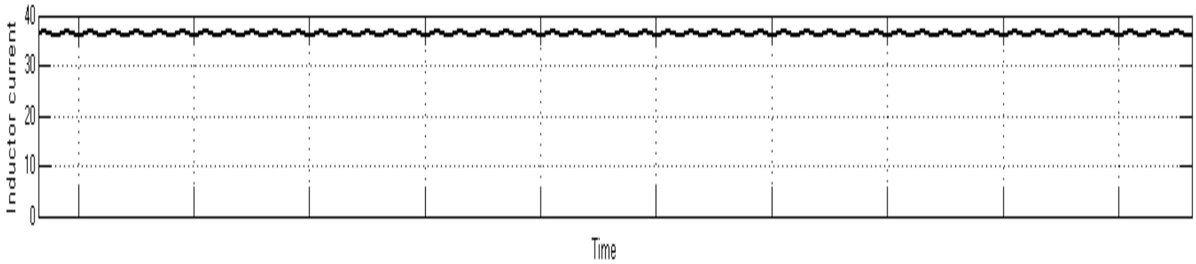



Fig 4.1(c) Current across inductor

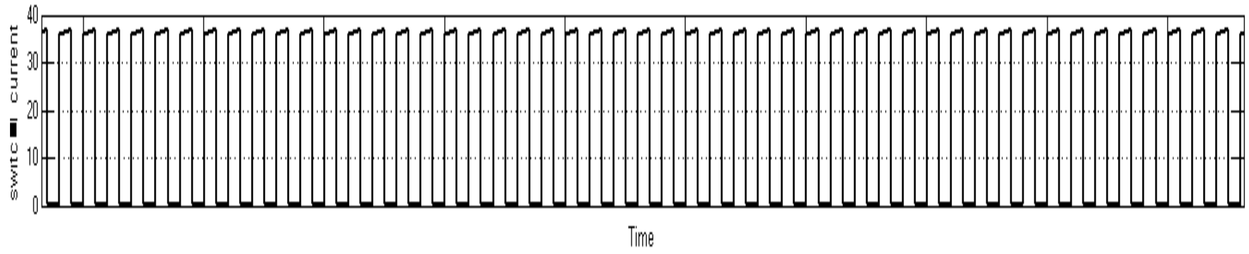



Fig 4.1(d) Current across switch (MOSFET)-1

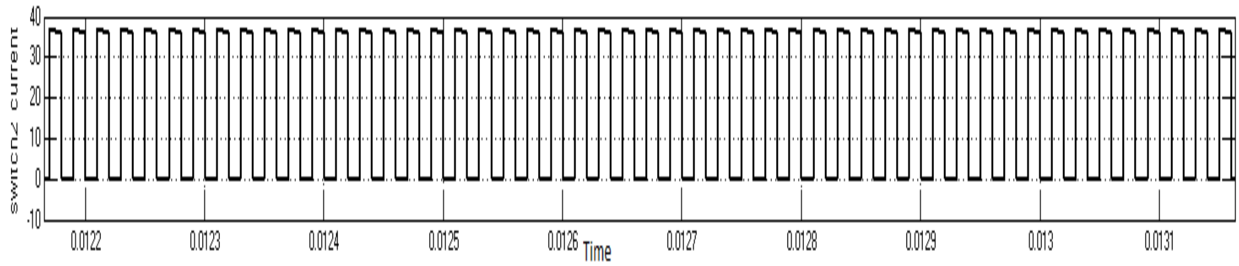
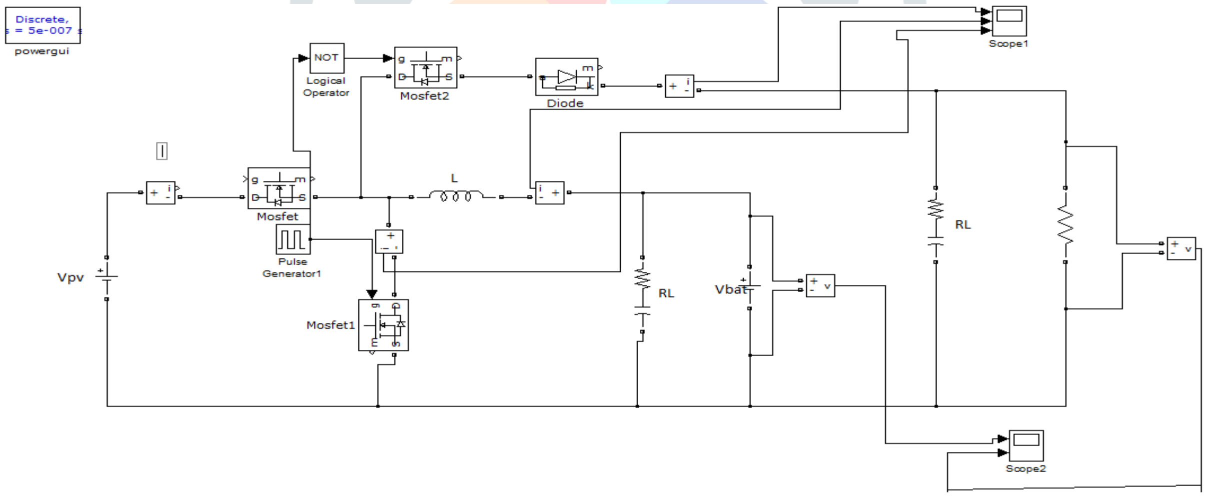



Fig 4.1(e) Current across switch (MOSFET)-2

**Discharging Mode:**




**Simulation Results for the discharging mode:**

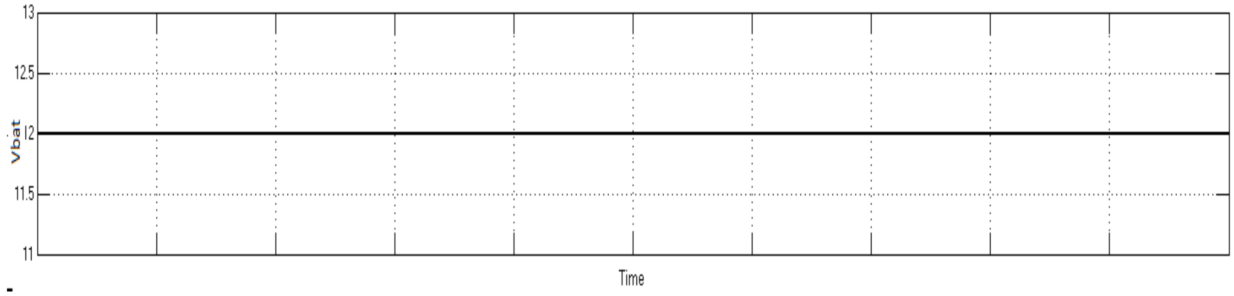



Fig 4.2(a) Battery voltage in Boost converter

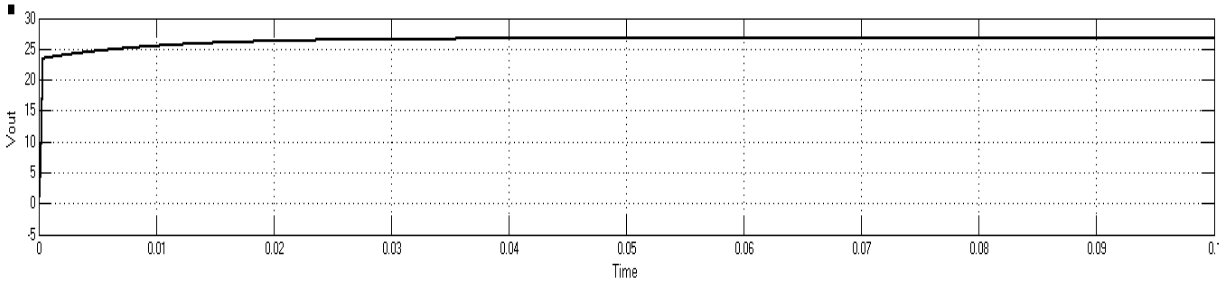



Fig 4.2(b) Output voltage in Boost converter

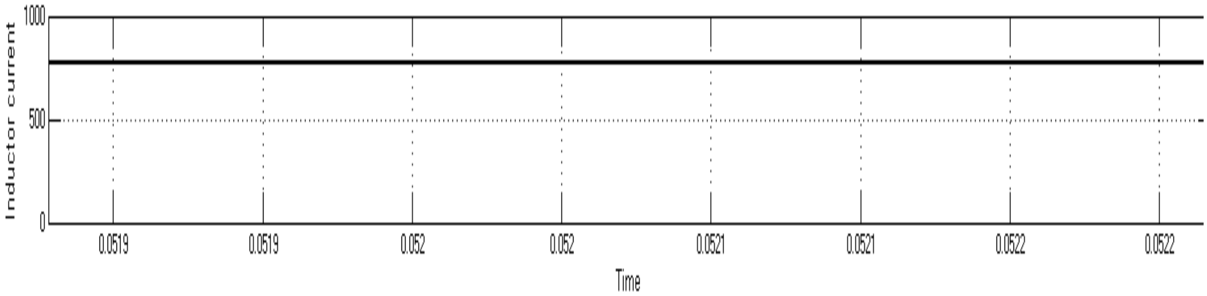



Fig 4.2(c) Current across inductor

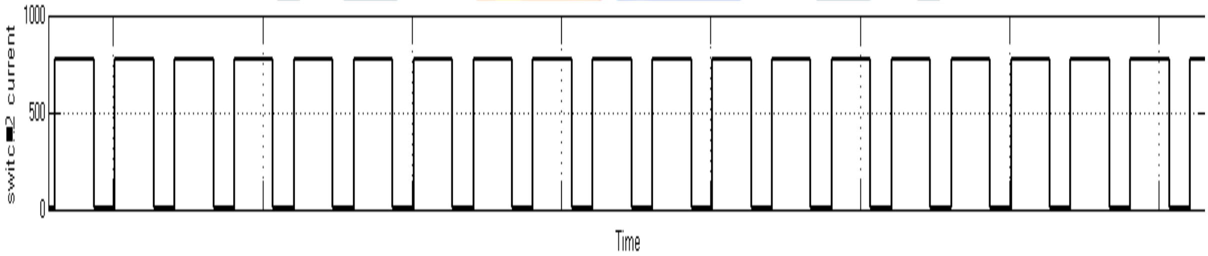



Fig 4.2(d) Current across switch (MOSFET)-2

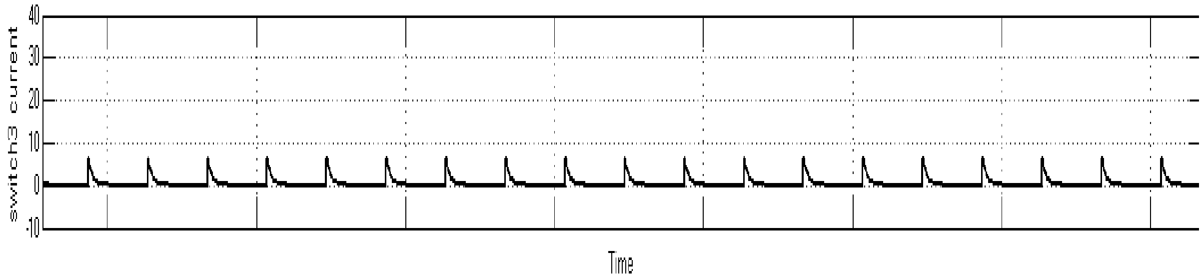



Fig 4.2(e) Current across switch (MOSFET)

### 4.1 Conclusion

This paper presents a DC-DC converter for the solar LED street lighting. In the day, the proposed converter is use to charge the battery from the solar module. In the night, the energy stored in the battery is transferred to the street lighting LEDs through the proposed converter. From the simulation results, one can see the performance of the proposed converter.

### 4.2 Future Scope

This paper can be implemented by using micro controllers in practical manner and can be extend this in closed loop system.

## V. Acknowledgment

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