International Journal of Engineering & Technology, 7 (3.24) (2018) 361-364

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Design of Current Controller for Stand-Alone Type Solar Street Light using Low-Cost Device

[1]Da-WoomJeong, [2]Young-Tae Ahn, [3]Seong-Mi Park, *[4]Sung-Jun Park

[1,4]Dept. of Electrical Engineering, Chonnam National University, Gwangju 61186, Korea
[2]Dept. Now Works, Gwangju 61003, Korea
[3]Dept. of Lift Design, Korea Lift College, Geochang 50141, Korea
**Corresponding author E-mail:* [1]Jeongdawoom89@gmail.com, [2]ytahn@hanmail.net, [3]seongmi@klc.ac.kr, *[4]sjpark1@jnu.ac.kr

Abstract

Background/Objectives: In recent years, the use of renewable energy tends to be drawing attention due to global warming and deterioration of environmental problems.
Methods/Statistical analysis: Electrical grid construction utilizing sunlight, which is attracting attention as a next generation energy source among them, is being actively advanced, and this paper focused on the design of street lights using solar power generation.
Findings: As a light source, energy saving and environmentally friendly LEDs were adopted. Due to the characteristics of the LED is sensitive to the current and temperature changes, so LED driving drivers for constant current control are required. Also, because the solar power generation time and the street lamp operation time are different, energy time shift is carried out through the battery, and because of the LED driving and battery charging needs constant current control, so constant current control design is indispensable.
Improvements/Applications: In this paper, in order to reduce the price burden in the design of the controller, we designed the battery charge drive and the LED driver using the low-cost device. We also constructed a solar street light system based on the proposed method and verified its validity.

***Keywords*: Solar Power, Street Light, LED, Battery, Buck Converter**

1. Introduction

In recent years, due to environmental problems, the use of renewable energy has been highlighted, and as one of the next generation energy sources, the electrical grid construction which utilizes solar power is actively performed. In this paper, we focused on the street lamps which occupy a large proportion of the average power consumption during a year. The trend of using solar energy to drive LED has increased significantly[1].At this time, in order to revitalize the stand-alone solar street light industry, it is indispensable to develop a low-cost solar charger and LED controller. Therefore, in this paper, we provide a topology for current controller design of solar street lights by using low cost voltage control elements for solar charge and LED control. We also constructed a solar street light system based on the proposed method and verified its validity[2,3].

2. Main Subject

Usually in the case of stand-alone solar street light, it develops through solar power on daytime and drives the LED from the energy developed at night. In this way, since energy generation time and consumption time are different from each other, an energy time shift function must be provided. At this time, Battery capable of charging and discharging electric energy is an energy time shift device which is currently commonly used. So the battery is located in an indispensable part of the next generation energy industry strategy[4,5].In addition, we have built a stand-alone solar street light using LEDs which are in the limelight as the next generation light source.

In the case of a typical stand-alone solar street light, the voltage level supplied from Solar Panel must be controlled according to the rating of the battery. For driving the LED from the battery for the same reason, it is necessary to control the voltage level according to the rating of the LED. At this time, the equipment used is power converter, among which, in this paper, Buck Converter was adopted[6,7].

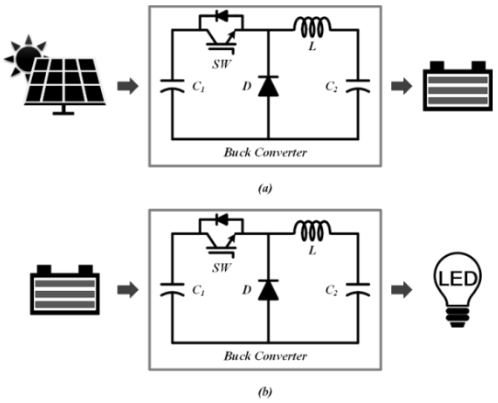

Figure 1:.General Street Light System Buck Converter

Figure 1 is a Buck Converter used for a typical stand-alone solar street light system. In the case of Buck Converter, it is a device that steps down the input voltage according to a desired voltage level. The Buck Converter consists of a switch element for voltage and current control, and a capacitor and an inductor for energy storage.

At this time, the switch occupies a large part at the price of the power converter. Therefore, instead of using an expensive switch, we replaced LM2576, which is a low-cost element, to expect price cuts in the overall system design. In the case of Battery and LED load, the characteristics of the load are varied via the constant current control method. For that purpose, a circuit for constant current control is further configured, and in this paper, the control circuit was constructed using LM2576 which is a low-cost element. However, in the case of the LM2576, since it is an element for voltage control, it was necessary to modify it and configure it as a system for current control[8,9].

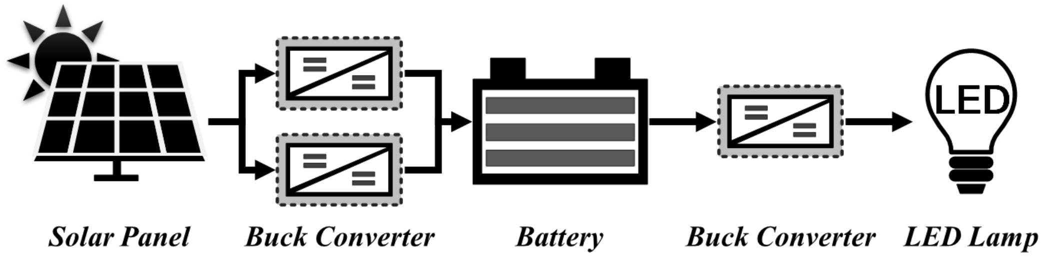

Figure 2:.Control Block Diagram of the Entire System

Figure 2 shows the overall system control block diagram. Looking at the overall control flow, DC power is supplied from Solar Panel. After that, connect two Buck Converters in parallel, control the voltage according to the battery rating, and then charge the battery. At this time, the reason for parallel control is that the maximum drive current of the LM2576 does not exceed 3 [A]. Therefore, it does not satisfy 5 [A] which is the standard charging current of the battery. Therefore, the condition was satisfied by controlling two Buck Converters in parallel. Battery is charged from this process. Thereafter, the charged power is a system that drives LEDs by varying from a single Buck Converter according to the rating of the LED[10].

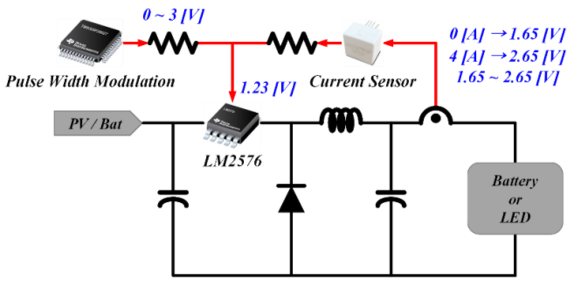

Figure 3:.Constant Current Control Circuit using LM2576

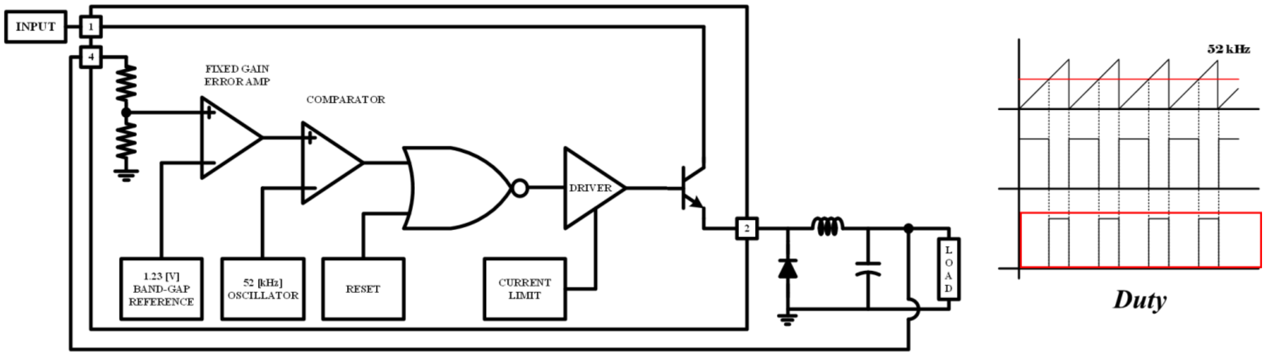

Figure 4:.LM2576 Operating as Switching Element

Figure 3 is a circuit diagram that uses the LM2576 to control the load current. In the current control circuit of the load side Battery and the LED, the output current of the Buck Converter is sensed and applied to the Current Sensor having linearity from 0 to 4 [A].At this time, it has an output voltage range of 1.65 [V] when the characteristic of Current Sensor is 0 [A] and 2.65 [V] when 4 [A].Thereafter, the output of the Current Sensor is applied to the Feed Back (FB) terminal of the LM2576.At this time, the FB terminal of the LM2576 should be maintained within the maximum allowable voltage of 1.23 [V] due to the characteristics of the device. Therefore, even if the output current of Buck Converter is varied depending on the situation, 1.23 [V] can be maintained through adjustment of duty ratio using PWM(Pulse Width Modulation).

As shown in Figure 4, the LM2576 acts as one switch element. The duty ratio is generated through PWM by comparing the output value of the oscillator which generates the carrier frequency of 52 [kHz] autonomously with 1.23 [V] which is the maximum allowable voltage of the LM2576 FB terminal. In this way, the LM 2576 acts as a single switching element. As a result, in this paper, we have constructed a low-cost system capable of constant current control from Battery and LED load.

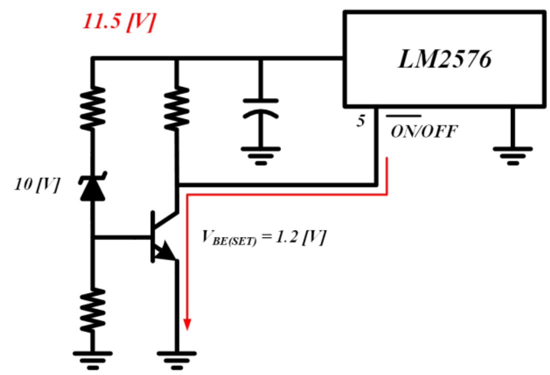

Figure 5:.Standby Power Reduction Circuit using LM2576

In the case of Figure 5, it is a circuit for reducing standby power by utilizing the ON/OFF function provided from the LM2576 element. As shown in the circuit of Figure 4, a voltage of at least 11.5 [V] should be applied to the circuit that satisfies the Zener-diode conduction voltage 10 [V] and switch conduction voltage 1.2 [V].Thereafter, the function of Pin 5 of LM2576 becomes effective, and the whole circuit operates. Therefore, when the output voltage of Solar Panel or Battery is less than 11.5 [V], the operation of the Regulator that supplies a constant voltage from each element is interrupted, and the power supply from the entire circuit is cut off. Therefore, since power is not supplied from the circuit in the standby state, unnecessary power loss can be reduced.

3. Simulation

Figure 6 and Figure 7 are simulation circuit diagrams using the actual fabricated stack and PSIM. Two Buck Converters are connected in parallel to charge the battery with the power supplied from Solar Panel. In addition, there is a single Buck Converter for driving the LED from the battery, and overall control from the DSP is being performed. In order to confirm the MPPT operation state, a switch for manually and automatically switching was installed, and a variable resistor was installed for adjusting the PWM value during MPPT manual operation. In addition, an LED for displaying the state of the battery SOC by color is installed. Solid green SOC 75 [%] or more, when lit in orange SOC 50 [%] or more, when lit red indicates SOC 25 [%] or more. Finally, we installed a test switch for checking the operation status of the LED and highlighted the convenience with a rotary switch to set the operation time of the LED.

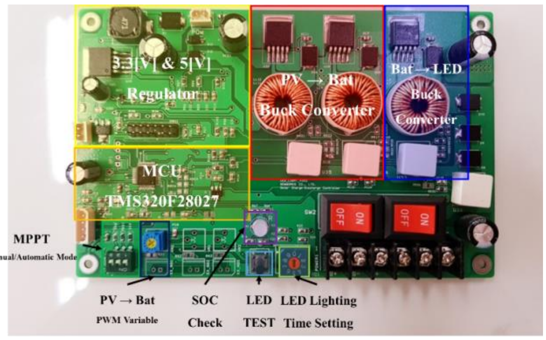

Figure 6:.Constant Current Drive System Made using LM2576

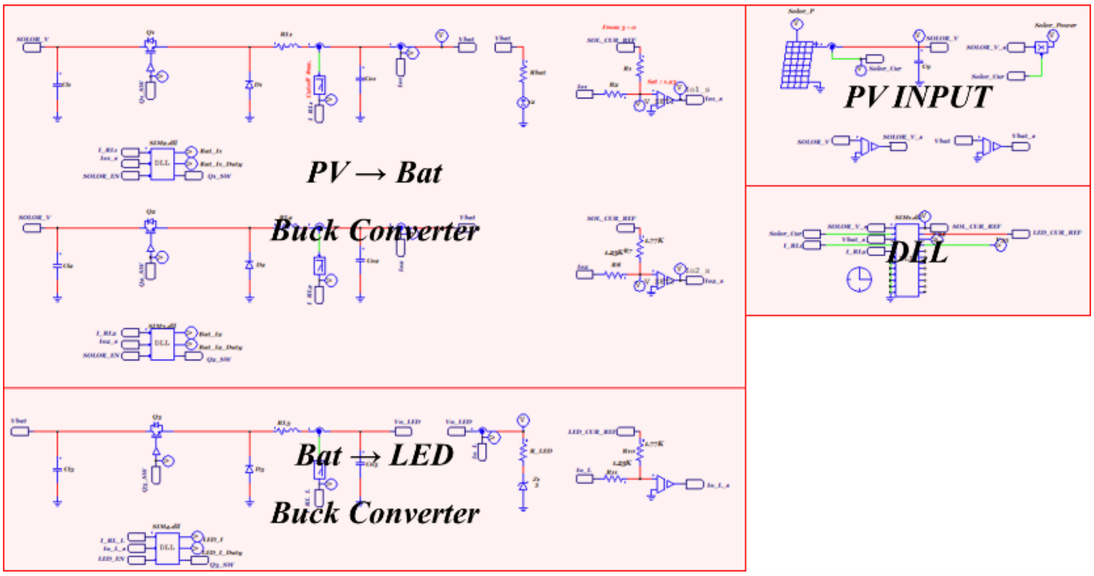

Figure 7:.Simulation Circuit Diagram using PSIM

Figure 8 shows the current waveforms of the two Buck Converters for charging the battery from the power supplied from the Solar Panel. It can be seen that the current is maintained constant through constant current control. It can be seen that the duty ratio accompanying it is also kept constant.

Figure 9 shows the current waveform of a single Buck Converter for LED drive from the battery. It can be seen that the current is maintained constant through constant current control. It can be seen that the duty ratio accompanying it is also kept constant.

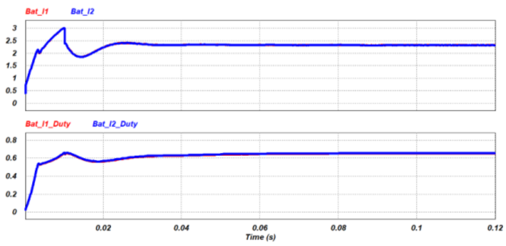

Figure 8:.Current Waveform and Duty Waveform When Charging Battery from PV

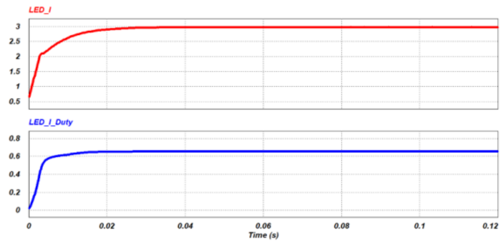

Figure 9:.Current Waveform and Duty Waveform When Driving LED from Battery

4. Conclusion

In this paper, the constant current controller of battery charging and a LED driving are not separately configured, and the Buck Converter was constructed using LM2576 which is low-cost. According to the characteristics of LM 2576, we can expect standby power reduction and over-discharge protection of Battery. Since the gate and the LED driver are not separately configured, it contributes greatly to securing economy. By using the certified product LM 2576, it can be expected to secure safety and reliability. Finally, a solar street light system was constructed by the proposed method and its validity was verified.

Acknowledgment

This work was supported by the Technological Innovation R&D Program (S2515720) funded by the Small and Medium Business Administration (SMBA, Korea)

References

[1] Awab Ali, Jonathan Lange, Ali Elrayyah, Yilmaz Sozer, J. A. De Abreu-Garcia,& Augustin Mpanda. (2018). A hybrid flyback LED driver with utility grid and renewable energy interface. *Consulting Psychology Journal: Applied Power Electronics Conference and Exposition (APEC)*, 3377-3384. doi :10.1109/APEC.2018.8341588.

[2] Fengge Zhang, Yuxin Wang, &Erxin Shang. (2008). Design and Realization of Controller in Wind Solar Hybrid Generating System. *Consulting Psychology Journal: Power System Technology and IEEE Power India Conference*, 1-6. doi :10.1109/ICPST.2008.4745372.

[3] LinlinGu, XinboRuan, Ming Xu, & Kai Yao. (2009). Means of Eliminating Electrolytic Capacitor in AC/DC Power Supplies for LED Lightings. *Consulting Psychology Journal: IEEE Transactions on Power Electronics*, 24(5), 1399-1408. doi :10.1109/TPEL.2009.2016662.

[4] Zhenhua Jiang, & Xunwei Yu. (2009). Modeling and control of an integrated wind power generation and energy storage system. *Consulting Psychology Journal: Power & Energy Society General Meeting*,1-8. doi :10.1109/PES.2009.5275753.

[5] S. S. Choi, K. J. Tseng, D. M. Vilathgamuwa, & T. D. Nguyen. (2008). Energy storage systems in distributed generation schemes. *Consulting Psychology Journal: Power and Energy Society General Meeting – Conversion and Delivery of Electrical Energy in the 21st Century*, 1-8. doi :10.1109/PES.2008.4596169.

[6] Yuanmao Ye, Ka Wai Eric Cheng, Jiongkang Lin, &Daohong Wang. (2015). Single-Switch Multichannel Current-Balancing LED Drive Circuits Based on Optimized SC Techniques. *Consulting Psychology Journal: IEEE Transactions on Industrial Electronics*, 62(8), 4761-4768. doi :10.1109/TIE.2015.2408813.

[7] Bangcheng Zhang, Hong Su, Xiaojing Yin, Minmin Chen, &ZhiGao. (2017). Research of the drive mode and reliability for rail vehicle LED drive system. *Consulting Psychology Journal: Prognostics and System Health Management Conference (PHM-Chengdu)*, 1-5. doi :10.1109/PHM.2016.7819951.

[8] Ruqi Li, Joyce Zhu, & ManjingXie. (2018). An improved analysis of dv/dt-induced low-side MOSFET false turn on in synchronous Buck Converter. *Consulting Psychology Journal: Applied Power Electronics Conference and Exposition (APEC)*, 2227-2234. doi :10.1109/APEC.2018.8341326.

[9] Ravindranath Tagore Yadlapalli,&AnuradhaKotapati. (2017). Efficieny analysis of Quadratic buck converter for LED lamp driver applications. *Consulting Psychology Journal: Trends in Electronics and Informatics (ICEI)*, 210-214. doi :10.1109/ICOEI.2017.8300917.

[10] D. Mounika, & S. Porpandiselvi. (2017). ADC controlled parallel loaded resonant half-bridge converter for LED lighting. *Consulting Psychology Journal: Communication and Electronics Systems (ICCES)*, 1031-1036. doi :10.1109/CESYS.2017.8321240.