

Direct battery-driven solar LED lighting using constant-power control

Bin-Juine Huang^{*}, Chun-Wei Chen, Po-Chien Hsu, Wei-Min Tseng, Min-Sheng Wu

New Energy Center, Department of Mechanical Engineering, National Taiwan University, Taipei 106, Taiwan

Received 21 February 2012; received in revised form 16 July 2012; accepted 23 July 2012

Available online 26 September 2012

Communicated by: Associate Editor Nicola Romeo

Abstract

A direct battery-driven LED lighting technique using constant-power control is proposed in the present study. A system dynamics model of LED luminaire was derived and used in the design of the feedback constant-power control system. The test result has shown that the power of 18 W and 100 W LED luminaires can be controlled accurately with error at 2–5%. A solar LED street lighting system using constant-power and dimming control was designed and built for field test in a remote area. The long-term performance was satisfactory and no any failure since the installation. Since no high-power capacitor is used in the present constant-power control circuit, a longer lifetime is expected.

© 2012 Elsevier Ltd. All rights reserved.

Keywords: LED driving; Stand-alone solar LED lighting; Solar LED lighting; Solar energy; LED; Solar lighting

1. Introduction

Application of stand-alone solar PV system in remote areas where the grid power cannot reach has been proved economically feasible. However, the reliability and continuous service time in a continuous bad weather are the two key factors influencing the acceptability of this technology.

A high-performance stand-alone solar LED lighting system was developed by Huang et al. (2010a) for LED lighting. The system adopts the near-maximum-power-point operation (nMPPO) concept for the design of photovoltaic power generation system (Huang et al., 2006) to get rid of the maximum-power-point-tracking controller (MPPT) just by properly matching the PV module specification with the battery voltage to obtain a similar performance of MPPT. The additional cost, reliability problem, and energy loss of the MPPT is thus avoided.

To charge the battery in its full storage capacity, a 3-phase battery charge using pulse-width modulation

(PWM) and feedback control technique was developed by Huang et al. (2010b).

Since the I – V curve of a LED lamp is sensitive in voltage, as shown in Fig. 1. A slight variation of applied voltage may cause abrupt change of current which may damage the LED. The constant-voltage driver was thus not recommended for LED. Instead, the constant-current driving is widely used in commercial products. A DC/DC converter with constant-current output for LED is thus needed in solar LED lighting system. This creates the problems of energy loss in the control circuit of the converter, decreasing solar system reliability, and increasing cost.

A lot of commercial DC/DC constant-current driver products for LED illumination are available. However, the energy conversion loss for high-power LED is high (>14%) at partial load condition, for example, the product of Zetex Semiconductors Plc. (2008). This happens when a dimming control of LED is employed. The cost of a DC/DC constant-current driver for 30–200 W LED is around 30–50 USD. Moreover, the lifetime of high-power DC/DC converter is expected to be around 3 years due to the capacitor failure in the circuit.

^{*} Corresponding author. Tel.: +886 2 23634790; fax: +886 2 23640549.
E-mail address: bjhuang@seed.net.tw (B.-J. Huang).

Nomenclatures

D_T	PWM signal duty cycle, dimensionless	K_p	proportional constant of PI controller
e	error signal from a comparator, $P_{set} - P_{ave}$ (W)	K_{vi}	gain of LED model $G_{vi}(s)$, Eq. (5)
$G_c(s)$	transfer function of controller in feedback system, Eq. (6)	LED _e	electric model of LED luminaire
G_{vi}	transfer function from LED voltage V_{bat} to current I_{LED} , Eq. (5)	LED _{ph}	photo-electrical model of LED luminaire
I	current to LED lamp, Eq. (1) (A)	P_{ave}	average power to LED luminaire (W)
I_{ave}	average current of LED, (A)	P_{set}	setting of input power (W)
I_{LED}	current through the LED luminaire (A)	$S^I(s)$	sensitivity function for variation of operating current, Eq. (8)
$T_{CL}(s)$	transfer function of the feedback control system, from setting power P_{set} to average power P_{ave} , Eq. (7)	$S^V(s)$	sensitivity function for variation of operating voltage, Eq. (9)
T_I	integral constant of PI controller	T_j	different junction temperature (°C)
		V	voltage of LED (V)
		V_{bat}	battery voltage to LED luminaire (V)

To eliminate the DC/DC converter for LED lighting, Huang et al. (2010a) developed a special technology to drive LED directly by battery voltage using a PWM technique with constant average current control. A reliability test for the illumination of LED lamps was performed continuously for 13,200 h and shows that the light decay of

PWM-driven LED is the same as that of constant-current driven LED.

The electrical performance of LED behaves like a negative-temperature resistance. The electrical resistance of LED decreases with increasing temperature. The driving voltage as well as the input power of a constant-current driven LED may change due to variation of LED junction temperature. An illumination test of a LED luminaire carried out in the present study shows that the constant-current driven LED causes an illumination decrease about 12%, and about 50% increase for constant-voltage driving, for a temperature rise of 40 °C (Fig. 2).

Huang et al. (2012) developed a constant-power LED driver using ac power input to balance the LED current supply as well as the light emission at variable operating temperatures. A linear feedback control technique was used in the design of constant-power LED driver. The test result shows that the feedback control system accurately controls the input power of LED luminaire to within 1.3 per cent error. As the ambient temperature changes from 0 to 40 °C, the LED illumination varies slightly (−1.7%) for constant-power driving, as compared to that of constant-current driving (−12%) and constant-voltage driving (+50%).

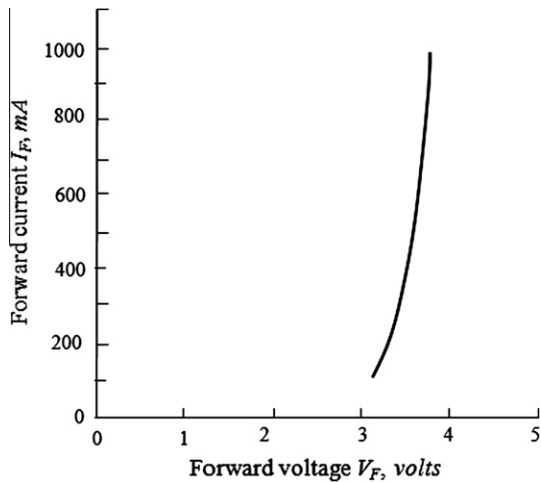


Fig. 1. I–V curve of a LED at junction temperature 25 °C.

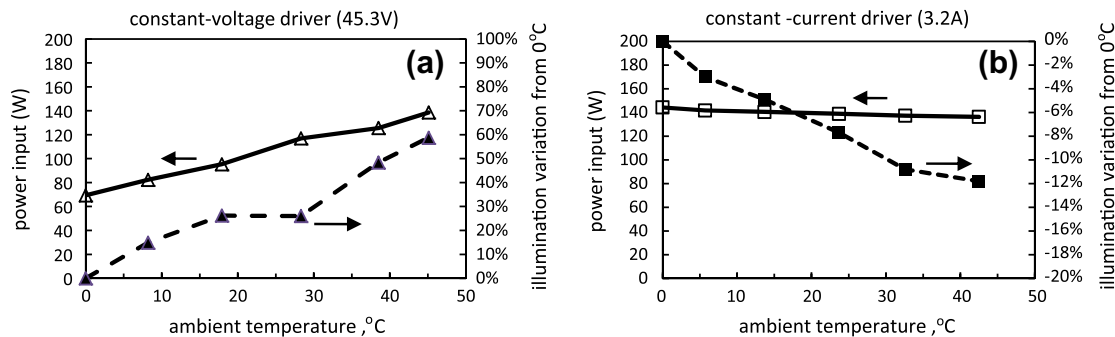


Fig. 2. Variation of LED illumination with ambient temperature for different driver.

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات