DESIGN NOTES

White LED Driver in Tiny SC70 Package Delivers High Efficiency and Uniform LED Brightness – Design Note 315

David Kim

Introduction

The LT®1937 step-up white LED driver is an ideal solution for small battery-powered portable devices such as cellular phones, PDAs and digital cameras. The LT1937 features an internal 36V switch that is capable of driving up to eight LEDs in series, but it is optimized for Li-Ion powered color display backlight applications that use two to four white LEDs. The LT1937 guarantees a constant light intensity and color in each LED, regardless of differences in their forward voltage drops due to a constant current step-up architecture that directly regulates the LED current. The constant 1.2MHz switching allows for the use of tiny external components and minimizes input and output ripple voltage—meeting the noise level requirements of products with sensitive wireless circuitry. The superior internal compensation of LT1937 lowers the output capacitor requirement to a single 0.22µF ceramic, saving space and cost. The low 95mV feedback voltage and an efficient internal switch minimize power losses in the LT1937. The result is a typical efficiency of 84%. The LT1937 is available in the tiny SC70 or 1mm tall ThinSOT™ package.

Li-Ion Powered Driver for Three White LEDs

Figure 1 shows a white LED driver circuit that is intended for small wireless devices. The constant current step-up series LED architecture of this circuit has much better efficiency than the alternative switched capacitor based parallel LED architecture. The circuit is designed to provide 15mA of constant current to drive three LEDs in series from a Li-Ion battery or 5V adapter input. The 1.2MHz constant frequency and superior internal compensation results in 0603 size ceramic input and output capacitors and a tiny ferrite core inductor (a chip inductor can be used to save even more space). The constant LED current is set with the R1 resistor at the feedback pin. By using a simple LED current calculation, $I_{LED} = 95mV/R1$ or $R1 = 95mV/I_{LED}$, a resistor value selection table is easily calculated (see Table 1). For accurate LED current, high precision (1%) resistors are needed.

Table 1. R1 Resistor Value Selection

I_{LED} (mA)	R1 (Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

Easy Dimming Control

The brightness of the LED can be adjusted using a PWM signal, a filtered PWM signal, a logic signal or a DC voltage. The brightness control using the PWM signal to $\overline{SHDN}$ pin and PWM dimming waveforms are shown in Figure 2. With the PWM signal applied to the $\overline{SHDN}$

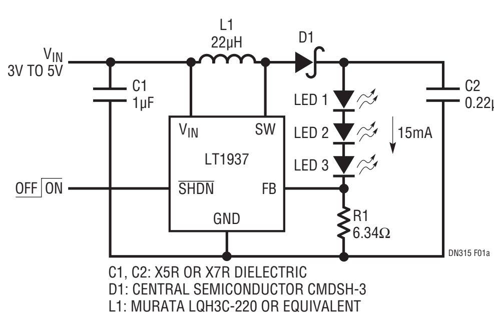
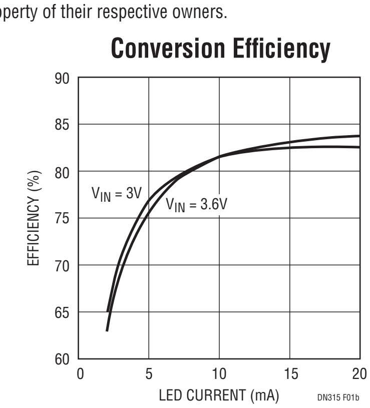


Figure 1. Li-Ion Powered Driver for Three White LEDs



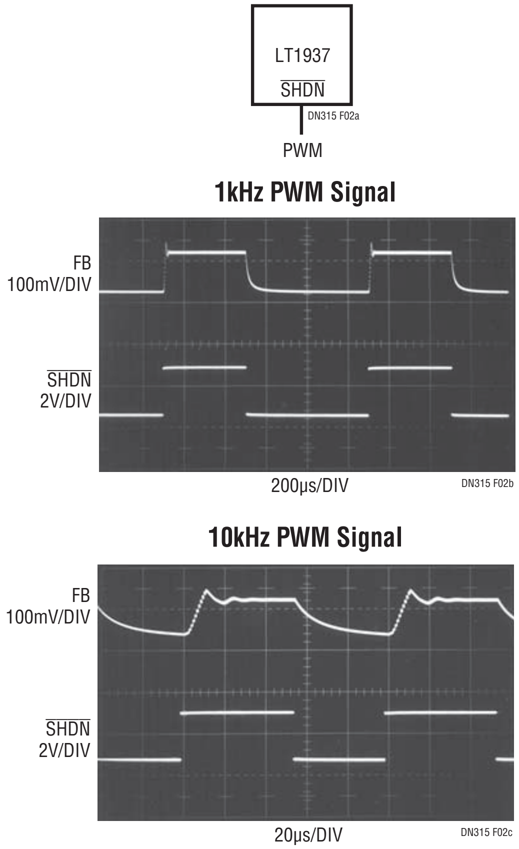


Figure 2. PWM Dimming Control Using the $\overline{\text{SHDN}}$ Pin

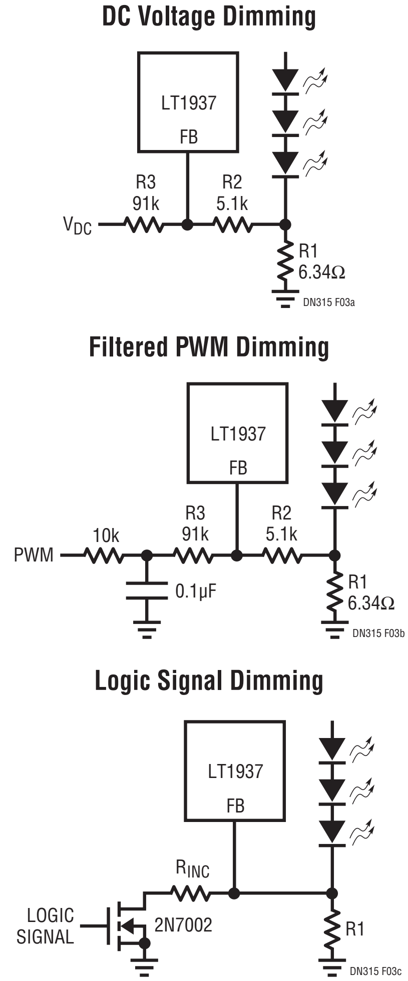


Figure 3. Dimming Control Methods

pin, the LT1937 is turned on or off by this signal. The average LED current increases proportionally with the duty cycle of the PWM signal, where 0% duty cycle sets the LED current to zero and a 100% duty cycle sets it to full current. The typical frequency range recommended for PWM dimming is for a 1kHz to 10kHz signal with at least a 1.5V amplitude.

Figure 3 shows alternative LED brightness control methods using a DC voltage, filtered PWM signal and logic signal. The DC voltage dimming control shown in Figure 3 is designed to control LED current from 0mA to 15mA using the 0V to 2V DC voltage at the V_{DC} input. As the voltage at the V_{DC} input increases, the voltage drop on R2 increases and voltage drop on R1 decreases, resulting in a decrease of LED current. The filtered PWM dimming works the same way except that the V_{DC} input now comes from a filtered PWM signal. The 10k, 0.1µF RC filters the PWM signal so that it is close to DC and the duty cycle of the PWM signal changes the DC voltage level. The LED current can also be adjusted in discrete steps using a logic signal dimming method shown in Figure 3. R1 sets the minimum LED current when the NMOS is off and R_{INC} increases LED current by reducing the resistor value when the NMOS is turned on.

Conclusion

The LT1937 is a white LED driver optimized for driving two to four LEDs from a Li-Ion battery input. With its 36V, 1.2MHz internal switch and superior internal compensation, the LT1937 is well suited for small wireless devices requiring very small circuit size, high efficiency and uniform LED brightness.

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

dn315f_conv LT/TP 0703 351.5K • PRINTED IN THE USA