DESIGN NOTES

High Efficiency ThinSOT White LED Driver Features Internal Switch and Schottky Diode – Design Note 325

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Introduction

The LT®3465 white LED driver is ideal for backlight circuits in small, battery-powered portable devices—such as cellular phones, PDAs and digital cameras. The LT3465 includes important features such as automatic soft-start to prevent large inrush current, open LED protection and an integrated Schottky diode in a low profile (<1mm) ThinSOT™ package to save space. The LT3465 is optimized for color display backlight applications with two to four white LEDs and a Li-Ion battery input. Even so, its internal 30V switch is capable of driving up to six LEDs in series.

The LT3465 uses a constant-current, step-up architecture which directly regulates the LED current and guarantees a consistent light intensity and color in each LED, regardless of the differences in their forward voltage drops. The constant 1.2MHz switching frequency allows the use of tiny external components and minimizes both input and output ripple for applications requiring low input and output noise. The internal compensation of the LT3465 reduces output capacitor requirements to a single 0.22µF ceramic capacitor—a significant space and cost savings over compensation schemes that have more strict output capacitance requirements.

The 200mV feedback voltage, high efficiency internal power switch and internal Schottky diode minimize power losses in the LT3465, resulting a typical efficiency of 80%. The LT3465 also comes in a 2.7MHz switching frequency version (LT3465A), allowing the use of even smaller components, such as chip inductors.

Li-Ion-Powered Driver for Four White LEDs

The compact white LED driver circuit shown in Figure 1 is designed to fit into small wireless devices such as cellular phones or PDAs. The efficiency of this circuit is higher than that of switched-capacitor based drivers in a parallel architecture due to the constant current step-up series LED architecture.

This design supplies 15mA of constant current, driving four LEDs in series from a Li-Ion battery or a 5V adapter input. The integrated Schottky diode, internal soft-start and open LED protection simplify the circuit and improve performance. The 1.2MHz constant frequency and integrated optimized compensation allow the use of small components, including tiny 0603-size ceramic input and output capacitors and a tiny inductor (an even smaller chip inductor can be used with the LT3465A). The LED current is programmed with resistor R1 at the feedback pin by the simple formula:

I_{LED} = 200mV/R1 or R1 = 200mV/I_{LED} (see Table 1).

Precision resistors (1%) are recommended for applications that require highly accurate LED current.

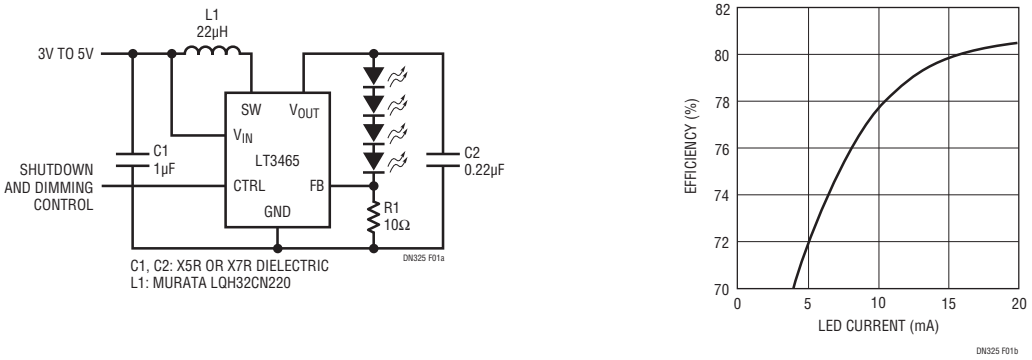

Figure 1. Li-Ion Powered Driver for Four White LEDs

Table 1. R1 Resistor Value Selection

FULL I_{LED} (mA)	R1 (Ω)
5	40.2
10	20.0
15	13.3
20	10.0

Dimming Control

The LT3465 features single pin shutdown and dimming control. By applying a DC voltage (Figure 2a) of 0.2V to ~1.5V at the CTRL pin (Pin 4), the feedback voltage changes from 25mV to 200mV. For a 20mA LED current application (R_{FB} = 10Ω), changing the CTRL pin voltage from 0.2V ~ 1.5V yields LED current from 2.5mA to 20mA. A CTRL voltage below 50mV will shut down the device. The curve in Figure 3 shows the correlation between V_{FB} vs V_{CTRL}.

Three dimming methods are shown in Figure 2 via a DC voltage, a filtered PWM signal and a logic signal. The first two methods adjust LED brightness by varying voltage at the CTRL pin and the logic signal method adjusts the brightness by changing the feedback voltage directly.

The filtered PWM dimming shown in Figure 2b works similar to DC voltage dimming except the V_{DC} input comes from a filtered PWM signal. The filter is the 5kΩ, 100nF RC circuit which filters the PWM signal to a DC voltage proportional to the duty cycle of the PWM signal. In this case, the LED current increases proportionally with the duty cycle of the PWM signal. A 100% duty cycle corresponds to full LED current, and a 0% duty cycle corresponds to zero LED current. The frequency recommended for filtered PWM dimming is 3kHz with a magnitude of 2V.

The logic signal dimming method (Figure 2c) uses an N-channel MOSFET and R_{INC} to reduce the value of R1 when a logic signal turns on the MOSFET. The value of R1 sets the minimum LED current and the parallel combination of R_{INC} and R1 sets the higher LED current. This simple circuit allows for a single dimming step. For more than two LED current levels, add additional MOSFET-R_{INC} circuits in parallel. Keep in mind that a separate logic signal is needed for each current setting and that the LED current calculation involves the parallel resistances of each $R_{INC}(n)$. With n switches on, $I_{LED}(n) = 200mV\ [R1||R_{INC}(1)...||R_{INC}(n)]$. The CTRL pin can still be used as different resistors are switched in to provide greater control of LED current.

Conclusion

The LT3465 is a white LED driver optimized for driving two to four LEDs from a Li-Ion input. It features a 36V, 1.2MHz internal power switch, internal Schottky diode, automatic soft-start, open LED protection and optimized internal compensation. The LT3465 is ideal for wireless devices requiring small circuit size, high efficiency and matching LED brightness.

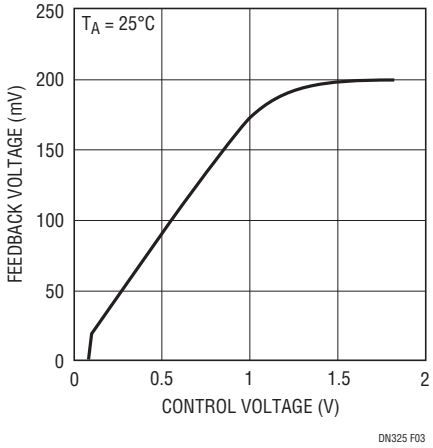

Figure 3. V_{FB} vs V_{CTRL} Correlation Curve

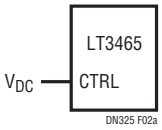

Figure 2a. DC Voltage Dimming

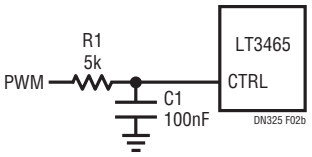

Figure 2b. Filtered PWM Dimming

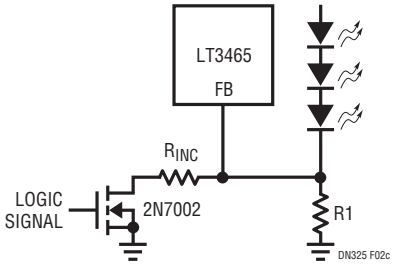

Figure 2c. Logic Signal Dimming

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