White LED Driver and OLED Driver with Integrated Schottkys and Output Disconnect in 3mm × 2mm DFN

by Alan Wei

Introduction

The LT3498 is a dual boost converter featuring both an LED driver and OLED driver in a single 3mm × 2mm DFN package. It provides an internal power switch and Schottky diode for each converter as well as an output disconnect PMOS for the OLED driver. Both converters can be independently shutdown and dimmed. This highly integrated power solution is ideal for dual display portable electronics with tight space constraints.

The LED driver is designed to drive up to six white LEDs in series from a Li-Ion cell. It is capable of regulating the LED current in a series configuration, providing equal brightness throughout an LED string regardless of variations in forward voltage drop. The 2.3MHz switching frequency allows the use of small external components and keeps switching noise out of critical wireless and audio bands. It features a high side LED current sense, which allows the converter to be used in a wide variety of application configurations. The LED driver also contains internal compensation, open-LED protection, analog or PWM controlled dimming, a 32V power switch and a 32V Schottky diode.

The OLED driver of the LT3498 features a novel control technique resulting in low output voltage ripple as well as high efficiency over a wide load range. During operation, the converter controls power delivery by varying both the peak inductor current and switch off time. The off time is not allowed to exceed a fixed level, guaranteeing that the switching frequency stays above the audio band. This unique control scheme makes it ideal for noise sensitive applications such as MP3 players and mobile phones. When operated by itself, the OLED driver consumes a low 230µA quiescent current, extending battery life in application modes where the LED driver is temporarily disabled.

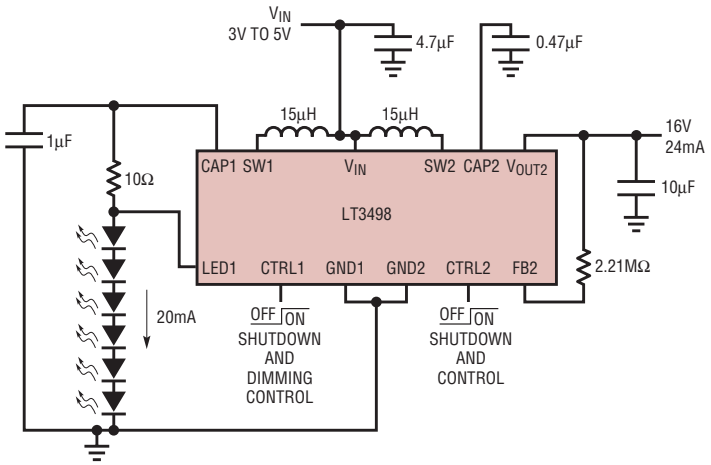

Figure 1. Li-Ion to six white LEDs and an OLED display

Figure 1 shows a typical application driving 6 LEDs and an OLED. Figures 2 and 3 show the efficiency of the LED driver and OLED driver respectively.

Features

LED Driver High Side Sense

The LED driver of the LT3498 features a unique high side LED current sense that enables the part to function as a 1-wire current source. This allows the cathode side of the bottom LED in the string to be returned to ground anywhere, resulting in a simple 1-wire LED connection. Traditional LED drivers use a grounded resistor to sense LED current, requiring a 2-wire connection to the LED string since the ground must return to the part ground. In addition, high side sense allows the LT3498 LED driver to operate in unique applications (buck mode or buck boost mode, where the LED string is returned to the input) where traditional LED drivers cannot be used.

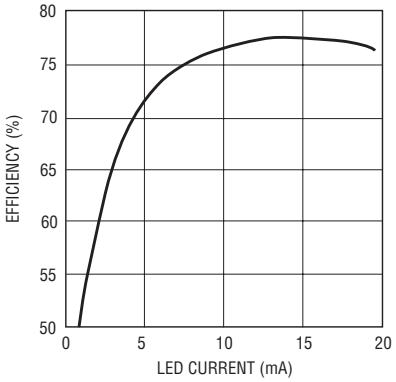

Figure 2. Efficiency of the LED driver in Figure 1

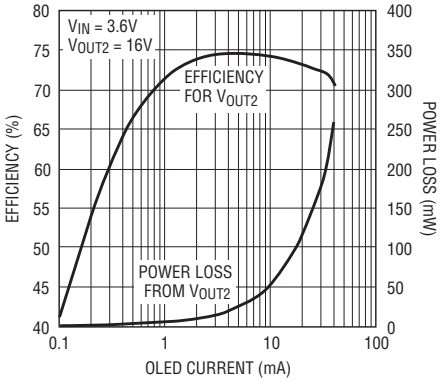

Figure 3. Efficiency of the OLED Driver in Figure 1

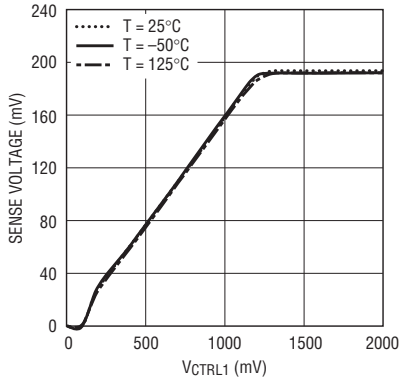

Figure 4. LED sense voltage vs CTRL1 pin voltage

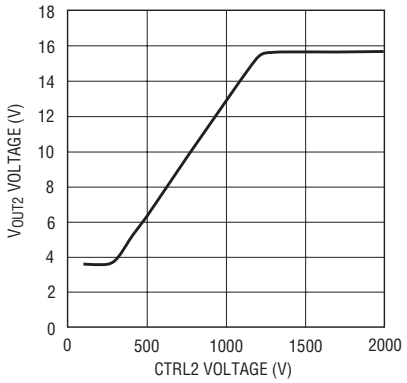

Figure 5. V_{OUT2} voltage vs CTRL2 pin voltage

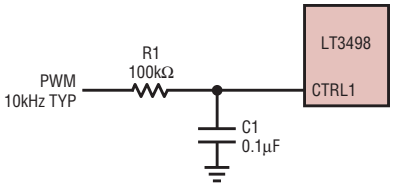

Figure 6. Filtered PWM dimming

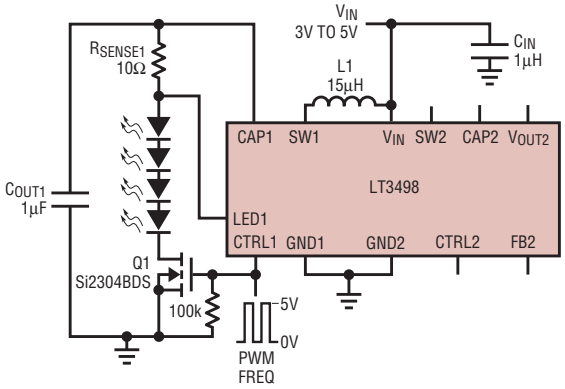

Figure 7. Li-Ion to four white LEDs with direct PWM dimming

Dimming & Shutdown Control

The LT3498 features a single pin shutdown and dimming control for each converter. To shutdown the LT3498, simply pull both control pins below 75mV. To enable each individual converter, increase the control pin (CTRL1 for the LED Driver and CTRL2 for the OLED Driver) voltage to 125mV or higher. On the LED side, the LED current can be set by modulating the CTRL1 pin. On the OLED side, the V_{OUT2} voltage can be set by modulating the CTRL2 pin. There are three types of dimming methods available in the LT3498: DC voltage dimming, filtered PWM signal dimming and direct PWM dimming.

The LED current and V_{OUT2} voltage are proportional to the DC voltages at the CTRL1 and CTRL2 pins, respectively. To dim the LEDs or lower the V_{OUT2} voltage, reduce the voltage on the CTRL1 and CTRL2 pins. The dimming range of the LED driver extends from 1.5V at the CTRL1 pin for full LED current down to 125mV. The CTRL1 pin directly controls the regulated sense voltage across the sense resistor that sets the LED current (see Figure 4). The CTRL2 pin regulates the V_{OUT2} voltage in a similar fashion as shown in Figure 5.

Filtered PWM dimming works similarly to DC voltage dimming, except that the DC voltage input to the CTRL pins comes from an RC-filtered PWM signal. The corner frequency of the R1 and C1 should be much lower than the frequency of the PWM signal for proper filtering. Filtered PWM dimming is shown in Figure 6.

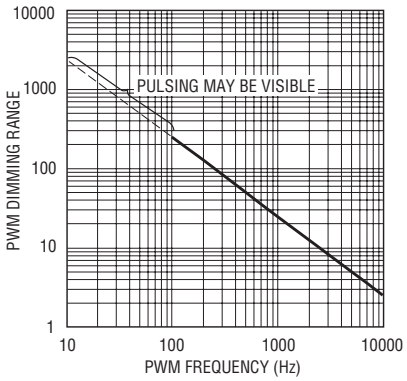

Figure 8. LED dimming range vs PWM dimming frequency

Direct PWM dimming is typically used because it achieves a much wider dimming range compared to using a filtered PWM or a DC voltage. Direct PWM dimming uses a MOSFET in series with the LED string to quickly connect and disconnect the LED string. Figure 7 displays direct PWM dimming of the LEDs in a Li-Ion to 4 white LED application. A PWM signal is applied to the CTRL pin and MOSFET where the PWM signal controls both the turn-on and turn-off of the part. Figure 8 shows the linearity of PWM dimming across a range of frequencies. The available dimming range depends on the settling time of the application and the PWM frequency used. The application in Figure 7 achieves a dimming range of 250:1 using a 100Hz PWM frequency.

OLED Driver PMOS Output Disconnect

The low-noise boost converter of the LT3498 features a PMOS output disconnect switch. This PMOS switch is

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three different current levels using a single programming resistor. The current ratios are selected using the ENT and ENF pins. Table 1 shows the three different current ratios, and the ENT/ENF settings required to select them. R_{SETT} refers to the resistor connected between the I_{SETT} pin and GND, and R_{SETF} refers to the resistor connected between the I_{SETF} pin and GND. In the case where single-resistor programming is desired, the I_{SETT} and I_{SETF} pins can be shorted together and connected to a resistor to GND. Figure 2 shows an example of this configuration, along with the resulting output current levels.

Dimming and Brightness Control

Figure 3 shows how the LTC3218 can be configured to control LED brightness with just a few external components. By pulse-width modulating the gate of M1, the reference current in resistor R1 can be varied. The maximum LED current is determined by:

$$I_{LED(MAX)} = \frac{850 \bullet 1.21V}{R_{SETT}}$$

where R_{SETT} = R1 + R2 and the on-resistance of M1 is small compared to R_{SETT}. Resistor R1 should be greater than 1kΩ to provide adequate isolation between the 1µF capacitor and the internal servo-amplifier.

Conclusion

Due to its small size and low external parts count, the LTC3218 is ideally suited for compact, camera LED applications. Features such as its single resistor programmability, multiple current ratios and 2-second flash timeout make the part simple to use, without the need for complicated control algorithms. Its low shutdown current and high efficiency make it perfect for situations where battery power is at a premium.

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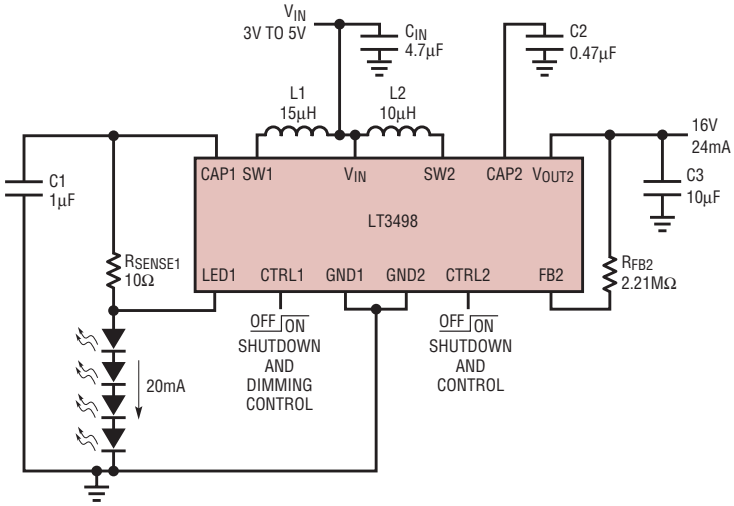
turned on when the part is enabled. When the part is in shutdown, the PMOS switch turns off, allowing the V_{OUT2} node to go to ground. This type of disconnect function is often required for OLED applications.

Li-Ion Powered Driver for Four White LEDs and OLED display

Figure 9 highlights the LT3498's simplicity and versatility. From a single 3mm × 2mm DFN, this circuit is capable of driving four LEDs in series, with 20mA of constant current as well as an OLED display. The efficiency for the LED driver in Figure 9 is shown in Figure 10. As shown above in Figure 1, the circuit can operate from a single Li-Ion battery (down to 3V) or 5V wall adapter and drive up to six LEDs in series at 20mA and an OLED display at 16V, 24mA out.

Conclusion

The LT3498 is a dual output boost converter that is capable of driving up to 6 white LEDs and an OLED display from a single-cell Li-Ion input. The device features 32V internal power switches, 32V internal Schottky diodes, independent DC or PWM dimming control, open LED protection, OLED output disconnect and internal compensation. The LT3498 offers a highly integrated, space-saving solution for a wide range of applications including space-constrained and noise-sensitive portable applications such as cellular phones, MP3 players and digital cameras.



CIN, C2: X5R OR X7R WITH SUFFICIENT VOLTAGE RATING
C1: TAIYO YUDEN GMK212BJ105KG
C3: TAIYO YUDEN TMK316BJ106ML
L1: MURATA LQH32CN150K53
L2: MURATA LQH32CN100K53

Figure 9. Li-Ion to four white LEDs and an OLED display

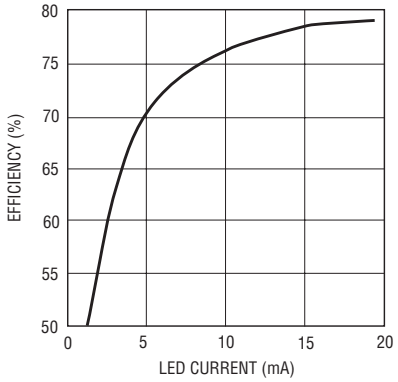


Figure 10. Efficiency of the LED driver in Figure 9