Using the TPS61042 white-light LED driver as a boost converter

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Applications, Portable Power

Introduction

Although designed to be a white-light LED driver, the TPS61042 can be configured as a discontinuous, hysteretically controlled boost converter with a 500-mA peak switch current. For example, Figure 1 shows the TPS61042 configured to provide $V_{OUT} = 16.2$ V and $I_{OUT} = 30$ mA, from $V_{IN}$ down to 2.5 V. The LED driver circuitry is either left unconnected (pins 1 and 2) or grounded (pin 7); and pin 5, CTRL, is used as enable.

Operation

As a boost converter, the TPS61042 operates with an input voltage range of 1.8 to 6 V and can generate output voltages of up to 28 V. The device operates in a pulse-frequency modulation (PFM) scheme with constant peak-current control. This control scheme maintains high efficiency over the entire load-current range. With a switching frequency of up to 1 MHz, the device enables the use of very small external components.

The converter monitors the output voltage. When the feedback voltage falls below the reference voltage (typically 0.25 V), the internal switch turns on and the current ramps up. The switch turns off when the inductor current reaches the internally set peak current of 500 mA (typ). Refer to the following paragraph, entitled “Peak-current control,” for more information. The second criterion that turns off the switch is the maximum on-time of 6 µs (typ). This limits the maximum on-time of the converter in extreme conditions. As the switch turns off, the external Schottky diode is forward-biased, delivering the current to the output. The switch remains off for a minimum of 400 ns (typ), or until the feedback voltage drops below the reference voltage. Using this peak-current control scheme, the converter operates in discontinuous conduction mode (DCM) where the switching frequency depends on the output current. This results in very high efficiency over the entire load-current range. Inherently stable, this regulation scheme allows a wide selection range for the inductor and output capacitor.

Peak-current control

The internal switch turns on until the inductor current reaches the typical dc current limit ($I_{LM}$) of 500 mA. Due to the 100-ns (typ) internal propagation delay, the actual current exceeds the dc current-limit threshold by a small amount. The typical peak-current limit can be calculated by

$$I_{P}(\text{typ}) = I_{LM} + \frac{V_{IN}}{L} \times 100 \text{ ns}$$

$$I_{P}(\text{typ}) = 500 \text{ mA} + \frac{V_{IN}}{L} \times 100 \text{ ns}.$$
The minimum inductor value, $L_{MIN}$, is a function of the output voltage, load current, and switching frequency and is calculated as

$$L_{MIN} = \frac{2 \times I_{LOAD} \times [V_{OUT} - V_{IN}(\text{min}) + V_D]}{I_p^2 \times f_{SMAX}},$$

where $I_p$ is the peak current as previously described under “Peak-current control,” $I_{LOAD}$ is the maximum load current, $V_D$ is the maximum rectifier diode forward voltage (0.3 V typ), and $f_{SMAX}$ is the maximum switching frequency (1 MHz).

A smaller inductor value gives a higher converter switching frequency but lowers the efficiency.

The best way to calculate the maximum available load current under certain operating conditions is to estimate the expected converter efficiency at the maximum load current. The maximum load current can be estimated by

$$I_{LOAD (max)} = \eta \times \frac{V_{IN}(\text{min}) \times I_p}{2 \times V_{OUT}},$$

where $\eta$ is the expected converter efficiency (typically 85%).

### Output capacitor selection

For the best output-voltage filtering, a low-ESR output capacitor is recommended. Ceramic capacitors have a low ESR value; but tantalum capacitors can also be used, depending on the application.

Assuming that the converter does not show double pulses or pulse bursts on the switch node (SW), the output voltage ripple can be calculated as

$$\Delta V_{OUT} = \frac{I_{OUT}}{C_{OUT}} \times \left[ \frac{1}{f_s} \times I_{OUT} - \frac{I_p \times L}{V_{OUT} + V_D - V_{IN}} \right] + I_p \times ESR,$$

where $I_p$ is the peak current as previously described under “Peak-current control,” $L$ is the selected inductor value, $I_{OUT}$ is the nominal load current, $f_s$ ($I_{OUT}$) is the switching frequency at the nominal load current as previously calculated, $V_D$ is the rectifier diode forward voltage (0.3 V typ), $C_{OUT}$ is the selected output capacitor, and ESR is the output capacitor ESR value.

Input capacitor selection

For good input-voltage filtering, low-ESR ceramic capacitors are recommended. A 4.7-µF ceramic input capacitor is sufficient for most applications. Increasing this value provides better input-voltage filtering. Refer to Table 1 for recommended input capacitors.

### Efficiency

As shown in Figure 2, the TPS61042's efficiency ranges from about 70% to 86% in a boost configuration.

The inductor and diode in Figure 1 were selected to minimize the overall area. A larger inductor and/or diode can improve efficiency.

### Related Web sites

analog.ti.com

www.ti.com/sc/device/TPS61042

<table>
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<tr>
<th>DEVICE</th>
<th>CAPACITOR</th>
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![Figure 2. TPS61042 boost-converter efficiency](image-url)
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