

Can't Find the Right Synchronous Boost LED Driver? Use a Synchronous Buck Converter Instead: Boost Mode Topology Drives 25V, 3A LEDs from 12V

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Synchronous buck converter drivers are commonly used when the current required for high power LEDs, such as 10A–40A projector LEDs, would overstress the components in a nonsynchronous converter. Synchronous rectification limits power losses and thermal rise due to high current in the converter switches. Synchronous rectification can offer the same benefits in high power step-up (boost) LED drivers—even with 1A to 3A LEDs. In contrast to a buck converter, the peak switch current of a boost can be much higher than the LED current, especially when output power is high and the input voltage is low.

There are a number of situations where a synchronous boost LED driver is not available for a particular application. For some of these cases, a synchronous buck LED driver IC can be used, but instead of operating as a step-down converter, it operates as a step-up, or *boost mode** LED driver.

For instance, take the LT3744 40V synchronous buck LED driver, which is designed to drive high current LEDs for projectors. It features a versatile, floating V_{EE} output that allows it to be used in both high current buck applications and positive-to-negative (buck-boost) topologies where

the anode of the high current LED is connected to ground to satisfy heat-sinking requirements. It is the floating V_{EE} feature that allows us to effectively use this part, originally designed for buck applications, as a synchronous boost mode LED driver.

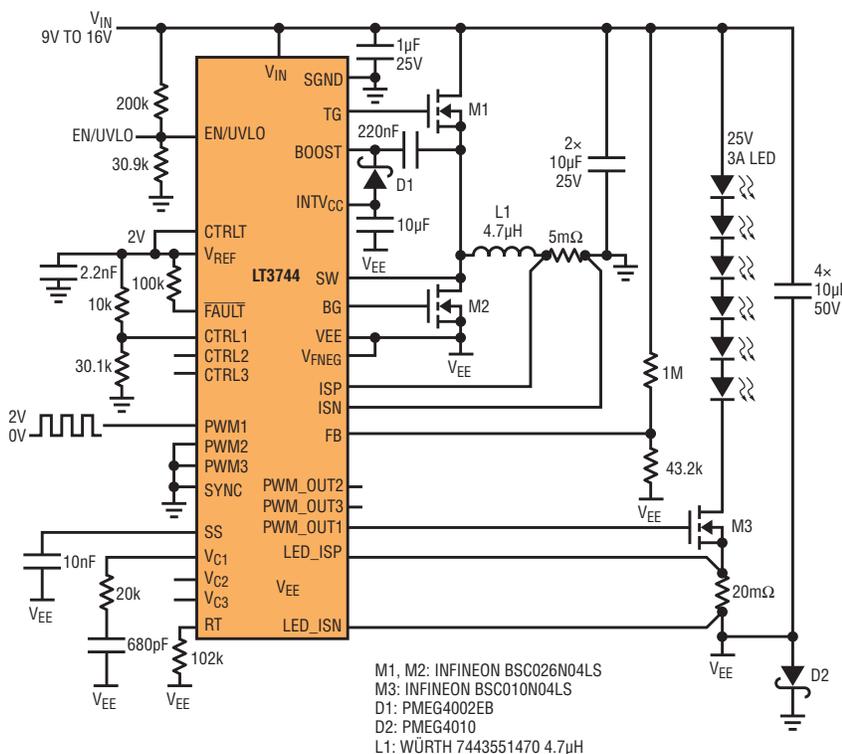
LT3744 BOOST MODE LED DRIVER

The LT3744 synchronous boost mode LED driver shown in Figure 1 regulates a 3A, 25V (75W) LED string from an automotive input (9V–16V) at 98% efficiency. Even at this power level, the maximum component temperature rise is 45°C with a 12V input, as shown in Figure 2. The IC enables easy implementation of both 10:1 analog and 100:1 PWM dimming at 120Hz with ground-referenced input signals, even though neither the LED string nor the PWM dimming MOSFET are connected to GND.

Although the 5mΩ sense resistor sets a 10A peak switch current in this application, the solution can be altered to operate with a 6V input and a 15A peak switch current; with an appropriately valued inductor and a lowered undervoltage lockout.

The negative V_{EE} rail on the LT3744 can reach -21V. The LT3744 simplifies design by handling the level-shifting of ground referenced input control signals.

Figure 1. Boost mode 9V–16V input to 25V, 3A LED driver with 98% efficiency



Synchronous rectification is a feature commonly called on to limit power losses in high power LED drivers. As shown, a synchronous buck LED driver can be used as a boost mode converter, capitalizing on the wide availability of this feature in high performance buck regulator ICs.

A simple ground referenced PWM input signal is level shifted to PWMOUT, so no additional level shifting circuitry is required to control the PWM MOSFET. Likewise, the LED current-setting sense resistor can be tied directly to the negative V_{EE} rail, all the way down to $-21V$.

LEVEL-SHIFTED GND AND V_{EE}

The level-shifting, positive-to-negative conversion, feature of the LT3744 LED driver is designed to support high current grounded-anode LED drivers. Nevertheless, the same feature can be used for boost mode applications where the LED string is connected between V_{IN} and a negative V_{EE} potential. Because the

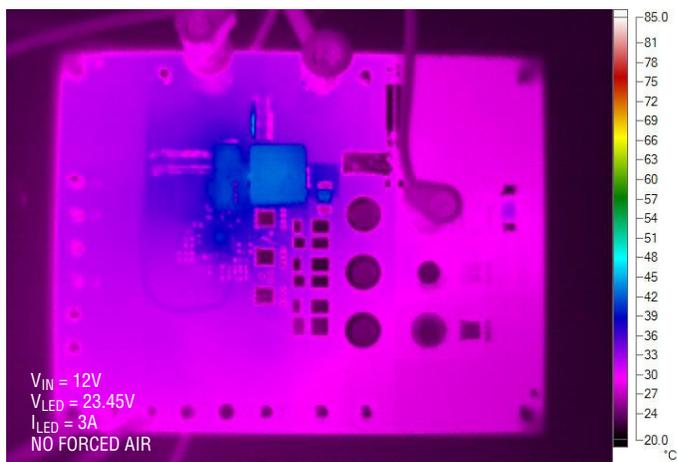
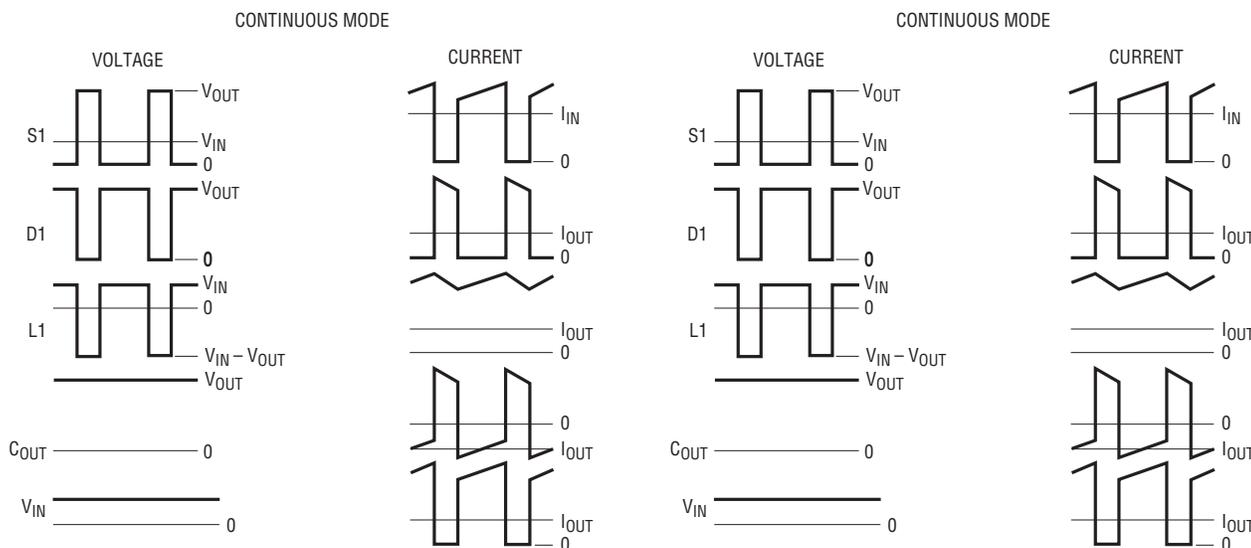
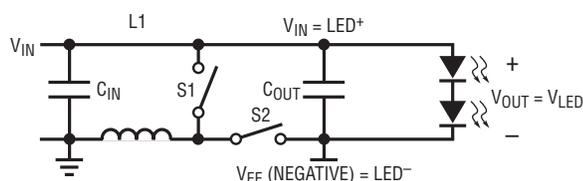
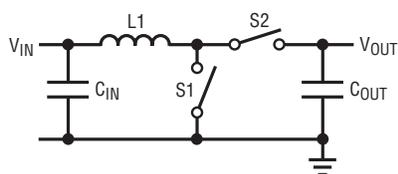


Figure 2. Boost mode LED thermal scan shows cool operation.

LED sense resistor and PWM dimming MOSFET are both located at the bottom of the LED string, the level-shifted

PWMOUT signal from the ground-referred PWM input yields a topology that looks no more complicated than a traditional

Figure 3. Boost mode current ripple, duty cycle and voltage stress are the same as those of traditional boost regulators.



The LT3744 synchronous buck LED driver can be used as a high efficiency 9V–16V input, 25V LED 3A boost mode LED driver, yielding 98% efficiency for a 75W converter. The unique ability of this IC to level shift control signals as needed from SGND to $-V_{EE}$ makes it possible to produce a floating boost mode topology with no more components than needed in a traditional boost.

boost PWM dimming setup. The input side looks like a straightforward LED driver, with CTRL analog dimming, SYNC input and enable inputs all referred to signal GND, no matter where negative V_{EE} lies.

The LT3744's V_{EE} can go all the way down to $-21V$. Open LED overvoltage protection is set at about 26.5V for the 25V V_{LED} application. With some open LED overshoot in mind, this limits the V_{IN} minimum to about 6V for a 25V V_{LED} boost mode application before negative V_{EE} goes beyond the $-21V$ limit. To operate at the minimum 6V input, the solution in Figure 1 requires a lower undervoltage lockout and a sense resistor and inductor that can accommodate 15A peak switch current limit. With lower V_{LED} strings (at any current level), the minimum input voltage can be dropped to 4V V_{IN} with some simple adjustments.

MORE ABOUT BOOST MODE

A boost mode converter has many of the same properties of traditional boost regulators. As shown in Figure 3, with the exception of the unusual topological hookup and the main control of high side switch S1 instead of a low side switch, this boost mode converter features the same duty cycle, ripple current and voltage stress that a tradition boost converter would. If synchronous rectification is not required, a nonsynchronous buck regulator can be used as a boost mode driver, with S2 replaced by a typical catch diode D1, as in a traditional boost regulator.

The gain-phase Bode plot in Figure 4 shows that even the control loop of boost mode converter acts like a traditional boost regulator. With a 10kHz crossover frequency, 60° of phase margin, and $-15dB$ of gain margin, the LED driver shown in Figure 1 is stable and reliable.

CONCLUSION

Synchronous rectification is a feature commonly called on to limit power losses in high power LED drivers. As shown here, a synchronous buck LED driver can be used as boost mode converter, capitalizing on the wide availability of this feature in high performance buck regulator ICs. Specifically, the LT3744 synchronous buck LED driver can be used as a high efficiency 9V–16V input, 25V LED 3A boost mode LED driver, yielding 98% efficiency for a 75W converter. The unique ability of this IC to level shift control signals as needed from SGND to $-V_{EE}$ makes it possible to produce a floating boost mode topology with no more components than needed in a traditional boost. ■

Notes:

* Boost mode is a patent pending technology.

Figure 4. Boost mode control loop gain and phase shows typical bandwidth.

