High-Power White LED Driver Runs Battery-Operated Portable Lighting

SANTOSH BHANDARKAR | Indian Space Research Organization, Bangalore, India santybh@yahoo.com

Many people consider white LEDs to be the future of lighting. Strung together, several LEDs can replace an incandescent lamp or a compact fluorescent lamp. High-power white LEDs need a dc

lamp. High-power white LEDs need a dc voltage of about 3.6 V at a current of about 350 mA to achieve full brightness,

about 40 lumens.

In portable applications, white LEDs are often powered by sealed lead-acid (SLA) batteries having a typical output of 12 V. The circuit shown in the figure takes this 12-V input and uses it to power a string of white LEDs. It features low cost, high efficiency, constant intensity independent of variations in battery voltage, dimming capability, and battery protection.

The driver circuit uses an SG1524 pulse-width modulation (PWM) switching

regulator (U1) operating in boost configuration. This configuration enables U1 to produce a maximum output of about 40 V, which can drive a string of up to 11 serially connected 1-W white LEDs. Because of the high power dissipation, the LEDs must be mounted with a suitable heatsink. The design of the driver involves the selection of an inductor, input capacitor, output capacitor, switching transistor, and output diode for a given operating frequency. Operating frequency is:

$$F_{OSC} = 1/(R1 * C1)$$
 (1)

A frequency of about 100 kHz is chosen for this example. Higher frequencies allow smaller inductances, but they also increase switching losses.

The battery's voltage is 13.2 V when fully charged and about 10.8 V under full discharge conditions. The voltage across the LEDs should be high enough to forward-bias the LEDs under varying input voltages. To ensure this, the required duty cycle is:

$$D = (V_{O} + V_{D} - V_{IN})/(V_{O} + V_{D} - V_{DS})$$
 (2)

where $V_{\rm O}$ = output voltage across the LED string; $V_{\rm D}$ = diode voltage drop; $V_{\rm IN}$ = minimum SLA voltage; and $V_{\rm DS}$ = MOS-FET voltage drop.

For an eight-LED string, V_0 = 28.8 V, $V_{\rm IN}$ = 11 V, and $V_{\rm D}$ = 0.4 V for the Schottky diode. Ignoring $V_{\rm DS}$, the required duty cycle is 62.3%. U1 has two independent switching transistors, each capable of

supplying about 100 mA and operating with a maximum duty cycle of 45%. To achieve the required duty cycle, the two transistors are connected in parallel. Since the LEDs need current higher than 100 mA, an external MOSFET is required.

To compute the value of L1, start with the average inductor current:

$$I_Lavg = I_O/(1 - D)$$
 (3)

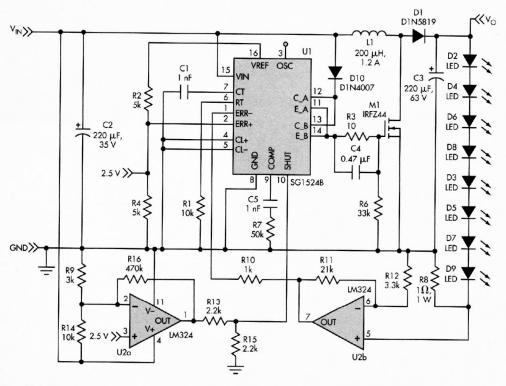
If the ripple in the inductor current dl_L is a certain percentage of the average current, the peak inductor current is:

$$I_{L}pk = I_{L}avg + dI_{L}/2$$
 (4)

Assuming 40% ripple over the average current, $I_Lpk = 1.12 A$. Therefore, the inductance is:

$$L = (V_{IN} * D)/(F_{OSC} * dI_{L})$$
 (5)

In this example, Equation 5 gives the minimum value of



This driver circuit for multiple white, high-power LEDs maintains constant light intensity with varying input voltage. It also provides dimming capability and protection against deep discharging of the battery.

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inductance as 184.3 μ H, where V_{IN} is 11 V. The output capacitor's value depends on the ripple allowed on the output voltage, while the input capacitor's value depends on the current peak.

To ensure constant illumination, the current through the LED must be monitored and maintained constant. To do this, the current is converted to voltage

by R8, R11, R12, and U2b and is fed back to the inverting terminal of U1's error amplifier. This negative feedback adjusts the duty cycle to maintain the current through the LEDs. Varying R11 provides dimming of the LEDs.

Op-amp U2a and R9, R13, R14, and R15 monitor the battery voltage and switch off the LEDs whenever the bat-

tery voltage falls below 11 V, thereby preventing deep discharge of the battery.

SANTOSH BHANDARKAR, a scientist/engineer with the Indian Space Research Organization in Bangalore, India, received a BE (electrical and electronics) from KREC Surathkal and an MTech (control and instrumentation) from IIT Bombay.

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