Low-Drop_ 0,6V_ Constant Current Source: for Ultrabright LEDs

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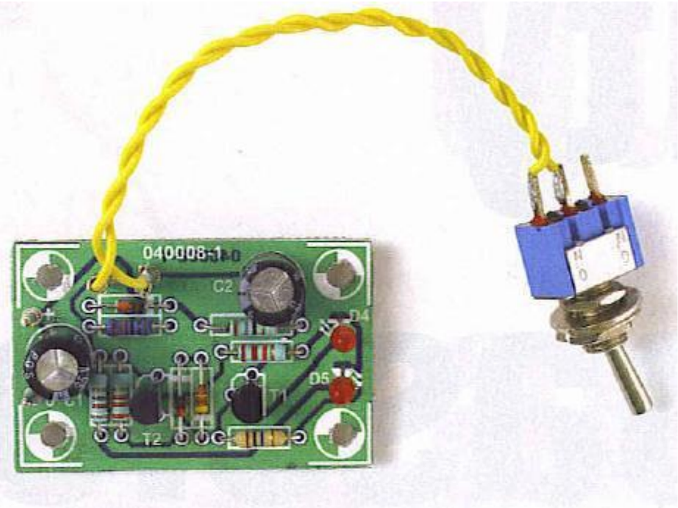

Ultrabright LEDs are becoming increasingly attractive for use in lighting and warning-signal applications. LEDs must be operated at a constant current to ensure that they continue to emit light at the same brightness. The usual approach is to use a series resistor, but in order to prevent the non-linear voltage/current characteristic, the NTC property of the LED and variations in the supply voltage from affecting brightness, we’d like to have something better.

The circuit described here is a low-drop constant current source for ultrabright LEDs with blinking capability, for use in headlights, taillighls, dog blinkers, light chains, car alarms and the like. It provides a constant current of 20 mA with a supply voltage of 4.5-30 V, or 50 mA with a 4.5-12 V supply. The voltage drop of the circuit is only 0.6 V, so practically the entire supply voltage can be used for the LEDs.

When the supply voltage is switched on, D5 generates a start-up voltage if the circuit is exposed to light (an LED can generate a photoelectric current). To enable the constant-current source to also reliably start up in the dark, R4 provides an initial base current to Tl and T2. In any case, both transistors initially only poss a small amount of current. But since each transistor provides the base current for the other one, the current rises to its setpoint value. The setpoint is stably maintained as follows. The voltage across D5, less the base-emitter voltage of T2, is also pres-ent across R3 (R5 has no effect at the beginning). A stabilized current thus flows through R3. Most of the constant current flowing through T2 comes from Dl and D2, with only a secondary contribution from the base current of Tl. The voltage across Dl and D2 is also stable, due to the stabilized current. This voltage, less the base-emitter voltage of Tl, is present across Rl, where it causes a constant current to flow through Tl and D5 (and D4 if present). This closes the loop. The circuit thus consists of two constant-current sources that stabilize each other. That’s the basic principle.

R2 increases the voltage across R3. This causes the current to be reduced proportional to the supply voltage, which further stabilizes the current. R2 is thus configured such that the current actually decreases slightly as the battery voltage increases. This causes Tl to be driven into full saturation at low voltages. D2 is intended to compensate for the base-emitter voltage of Tl, while Schottky diode Dl provides the ’miserly’ voltage drop across Rl. Dl and D2 are thermally coupled to Tl. As a result, with increasing temperature the current is more likely to decrease than increase. LED D4 is included in the circuit to prevent T2 from having to go into saturation at low operating voltages. That wrings out an extra 0.2 V or so. In this way, the battery is mercilessly sucked dry when is becomes weak. It’s totally defenseless. However, rechargeable batteries should never be deep-discharged!

Overvoltage protection should be included if the circuit is intended to be used for general experimentation or with LED chains. In case of overvoltage, D3 starts conducting and takes current away from T2 (which is essentially what R2 does as well). To prevent overheating of Tl, particularly with a current of 50 mA, the current is sharply reduced for voltages greater than approximately 15 V. The upper voltage limit is then practically determined solely by the maximum collector voltage (Uce) ratings of the two transistors.

An LED chain can best be inserted in series with the supply voltage, in order to avoid making any changes to the circuit. Naturally, at least D5 must still remain in the circuit.

R5 and C2 form part of the blinking circuit. R5 and CI smooth out large current spikes and RF oscillations during blinking operation. Low-impedance feedback is provided by C2. The resulting pulses are long enough to be clearly visible and short enough to use as little energy as possible. The duty cycle is only 10 %. However, at base voltages less than 5 V (with two LEDs fitted) it increases to 50 %, with an accompanying decrease in current. Below 4.6 V, shortly before the circuit 'runs dry', the pulse heads toward to zero. The 10-% pulses achieve the rated pulse current level of 100 mA for 50-mA LEDs, and they have such steep edges that two blinkers connected to a single power source blink in unison if they are not decoupled by at least 1Ω. The voltage fluctuations on C2 are so small (approximately 0.6 V) that hardly any energy is lost.

We have designed a small printed circuit board for the constant-current source, which could hardly be easier to build and does not require any comments. Diodes Dl and D2 are placed immediately next to Tl and thus adequately thermally coupled. For a maximum constant current of 50 mA, the value of Rl should be 6.8 Q, while for 20 mA a value of 18Ω should be used. Naturally, the value of Rl can be increased even more to reduce the value of the constant current any the desired level.

If Tl does not have the anticipated cur-rent gain of 140, R3 should be reduced to 680 Q. The current flowing through diodes Dl and D2 should be at least three times the base current of Tl. Naturally, the base current Rowing through T2 is not multiplied. The value of 1x3 is thus 4 x /BT1 (since feT2 can be neglected). As D5 determines the voltage across R3, we thus have the formula:

$R3 \le \beta T1 \times [[UD4 - 0.65 V) / (4Lconst)]$

The maximum permissible value of UR1 is 340 mV. From the author's experience, when setting the level of the constant current it helps to try several diodes for D2 with different tolerance values. In stubborn cases of excessively high current levels (or if you want to be on the safe side but don't want to or can't measure, adjust or whatever), you can simply connect two lN4148s in parallel. This will cause the operating point to lie somewhat lower on the characteristic curve.

Another important tip for avoiding eye injury (retina damage): never look directly at an ultrabright LED, especially in the dark!