1.5-V White LED

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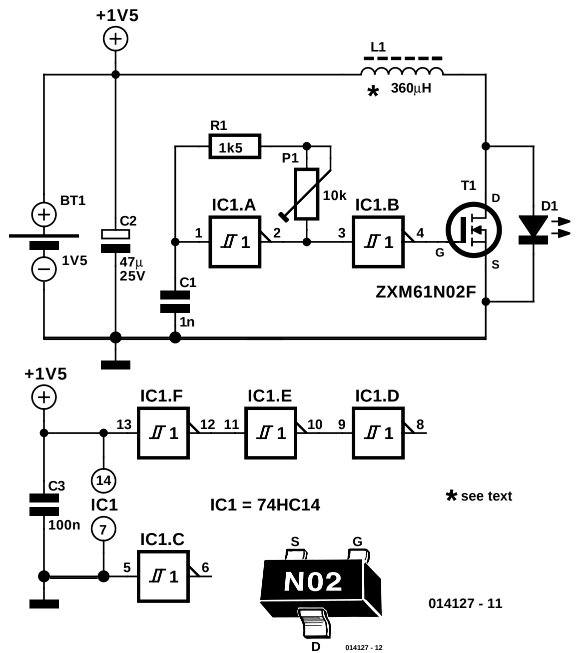
Thanks to their high light output and long lifetimes, a white LED is an excellent choice as a replacement for the incandescent bulb in a penlight torch. However, there is a 'but'. Depending on the current level, white LEDs need a voltage of 3 to 4 V. You thus need a penlight with at least three batteries, which is not exactly what you can call compact. Fortunately, this problem can be remedied using a simple adapter circuit.
The design described here allows a white LED to be operated from a single 1.5-V battery. It consists of a simple step-up converter and an oscillator. If the circuit is built using SMD components as much as possible, it will not be difficult to fit everything into the torch.
The actual step-up converter consists of L1 and T1. The coil is wound on an EP7 core, which consists of a spool, two core halves (T-38 core material) and a clip/screen. It is available from Farnell, among others. Wind 17 turns of 0.5-mm enamelled copper wire on the spool. If you make the windings neat and tight, the core halves will just pass over the wound coil. Handle the spool carefully, since it breaks easily. The inductance of the coil made in this manner is around 360 μH, and it has a Q of 50 (at 1 kHz.).

A Zetex SMD transistor (ZXM61N02F) was used for the prototype. This miniscule MOSFET has a very low $R_{DS(ON)}$ and a low threshold voltage.

The driver oscillator for T1 is a classical R–C oscillator using a Schmitt-trigger inverter (IC1a, a Texas Instruments 74HC14). This proved to still work at 1.5 V. The frequency has been made adjustable so that the brightness can be increased when the battery is low by changing the frequency. There is an optimum setting, since the battery voltage drops when the battery is nearly empty and a large current is drawn. With a full battery, the lowest frequency gives the largest current. With the indicated component values, the frequency can be set between 50 kHz and 300 kHz. The brightness is greatest at the lowest frequency with a full battery; in this situation the current consumption is 16 mA and the efficiency is 84%.

The working principle of the converter is simple. When T1 conducts, the current through L steadily increases; at 50 kHz and a duty cycle of 50%, it will reach a value of 40 mA. When T1 stops conducting, the current in the coil continues to flow through D1. The inductive voltage across T1 is limited by D1.

The current through the white LED may be as high as 20 mA (in our case). Although the current peaks rise as high as 40 mA, the average value is significantly lower.



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