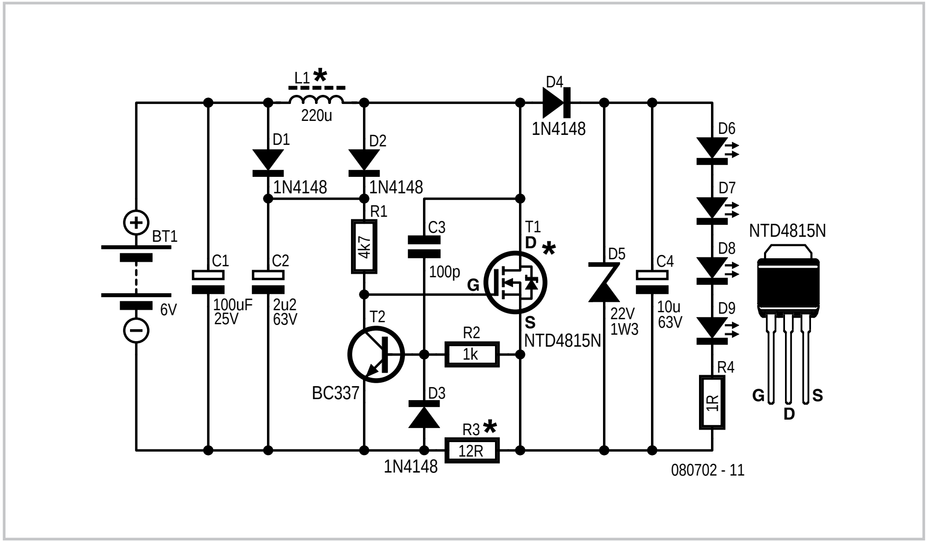
LED Bicycle Lights

Ian Field (United Kingdom)



Before getting started an acknowledgement is due, the circuit presented here uses an ingenious method of controlling a flyback converter by the voltage developed on a current sensing resistor, this was published by Andrew Armstrong in the July 1992 issue of ETI magazine.

The reworked circuit is quite simple. At the instant that power is applied only a small current flows to charge C4 so insufficient voltage is developed on R3 to switch T2 on. Also, D1 allows C2 to charge from the 6 V battery, so R1 feeds enough voltage to switch on T1 — this shunts the voltage across L1 and the current in it starts to rise. At a certain point the current which returns via R3 will develop sufficient voltage to switch on T2 which shunts the gate voltage to T1 causing it to switch off, initiating the flyback voltage from L1. The flyback pulse forces a current around the circuit, charging C4 and feeding the LEDs. As the return current is via the current sensing resistor R3, this keeps T2 turned on and T1 turned off, so the flyback phase is not clamped until it has given up all its energy. Capacitor C3 provides positive feedback to ensure reliable oscillation and sharpen up the switching edges. Components D1, D2 & C2 form a bootstrap boost circuit for the MOSFET gate, although it is logic level it only guarantees the stated $R_{D\text{-}S(on)}$ at a V_g level of about 8 V — by happy coincidence the combined V_f of four ultrabright red LEDs is about 8.8 V and this is the value that the output is normally clamped to.

There are some notes on the components specified. For position T1 an n-channel MOSFET with a very low $R_{D\text{-}S(on)}$ of 15 mΩ (at 10 V) Is suggested, although its high I_D rating (35 A) is not strictly necessary. Purists may wish to use Schottky barrier diodes for D2 and D4, but a quick look at the data sheet for the popular BAT85 shows that with a T_{rr} of 4 ns it is not actually any faster than the 1N4148. It is doubtful whether the lower V_f would make any noticeable difference.

Zener diode D5 has been included as a safety measure in case the output should ever find itself open circuit. The flyback converter can develop a quite impressive voltage when run without load and would have no difficulty damaging the MOSFET. If a higher voltage MOSFET is used then C4 could easily fall prey to excessive voltage if the lead to the LED breaks. In the final working prototype D5 was a 1.3-watt 22-volt zener, but any value between 18 and 24 V is fine. Bear in mind that with four white LEDs on the output the voltage will be somewhere in the region of 13 V. L1 is a 9 mm diameter 0.56 A 220 µH inductor with a low DC resistance (Farnell # 8094837); don't even think about using those small axial lead inductors disguised as resistors — even the fat ones last only a few seconds before failing with shorted turns.

On R3, this resistor is selected depending on the configuration of LEDs. A value of 20 mA is fairly typical for 5 mm LEDs, on this basis four red LEDs will need about 12 Ω; five red LEDs about 10 Ω, and four white LEDs about 6.8 Ω. Resistor R4 (1 Ω 1%) is provided to use as a temporary connection for the LEDs' negative lead so the volt drop can be measured to indicate the current flowing during setting the correct LED current by adjusting R3.

The efficiency of the circuit depends on the LED current, which also determines to some extent the switching frequency. At 10 mA (4 white LEDs) 170 kHz was measured on the prototype — and that's about the maximum normal electrolytic capacitors are able to withstand. If more current is drawn (e.g. three white LEDs at 30 mA) then the switching frequency drops to about 130 kHz and the efficiency rises to around 75%.

The circuit is simple enough to construct on stripboard, which can be built as a single or double unit to suit whatever lamp housings are ready to hand. The double unit should fit comfortably in a 2x D cell compartment and the single board is only a whisker bigger than a single C cell.

Suggested lamp housings are the Ever Ready and the Ultralight but there should be many others that can be modified to house the stripboard. In many cases the hole for the bulb will need 4 notches cut with a round file so that the LEDs can be pushed far enough through. These can be secured in place with a spot of hot melt glue.

The battery and switch box can be surprisingly challenging, the unit built for a family member went on a bicycle with a wire basket so it was easy to bolt a Maplin ABS project box to that. With only the tubular frame to fix things onto, it's not so easy. The authors' battery box for the present project is an old Halfords lamp — the one that drops into a U shaped plastic clip that does nothing to deter thieves, but it's far more secure when cut down to make a battery box and clamped to the handlebar with a jubilee clip. It easily holds a 6 V 1.3 Ah SLA battery from Maplin but any nominal 6 V type can be used as per individual preference. Deep discharging should be prevented.

Please Note. Bicycle lighting is subject to legal restrictions, traffic laws and, additionally in some countries, type approval.

(080702-I)