

# LEDify It!



## Mobile 3-watt LED Lamp

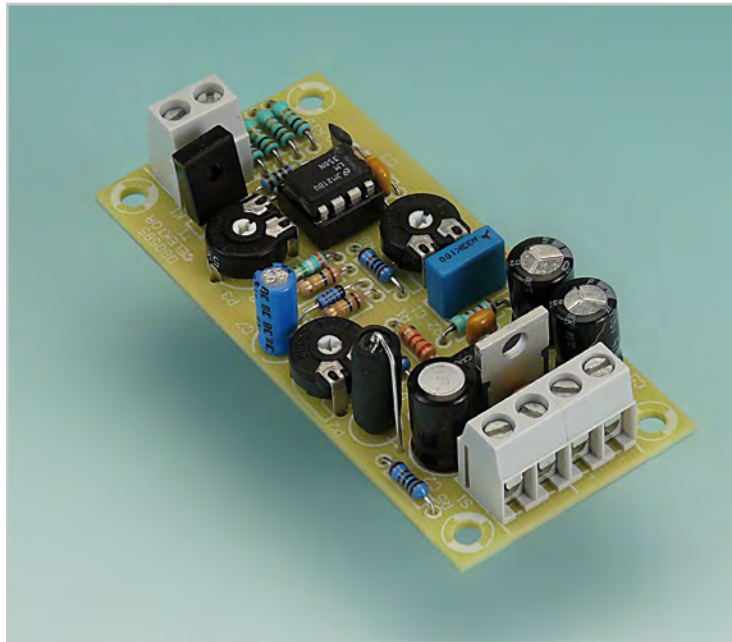
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A traditional hand-held torch could hardly be described as a cutting-edge piece of technology; in fact it's probably the exact opposite, circuits don't come much simpler! Text books have for years used a battery, light bulb and switch to describe just what a circuit is. We are also aware of the shortcomings of the filament lamp; the light dims as the battery discharges and occasionally you need to replace a burned-out bulb. Why not treat an old torch to a 21st century make-over? Replace the bulb with more efficient LEDs, the 5 mm 70 mW types will not be very illuminating but 1-watt white LEDs are now reasonably priced.

It's not quite as simple as removing the bulb and replacing it with an LED. Unlike a fila-

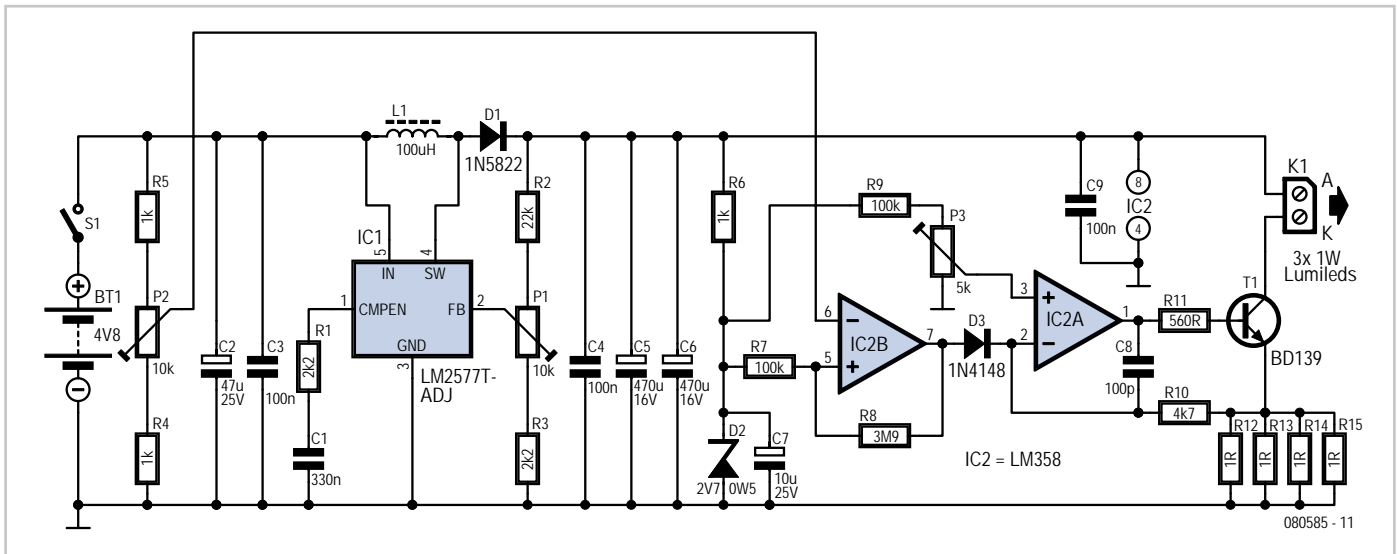
### Features

- Three 1 W LEDs powered from 4.8 V
- Efficiency > 80 %
- Light output independent of battery voltage
- Battery deep-discharge protection



ment bulb an LED exhibits differential resistance i.e. its resistance depends on the applied voltage. It is necessary to supply it with a constant current. This can be achieved (approximately) by using a series resistor but power loss in the resistor reduces efficiency. Also, light output will decrease as the battery voltage

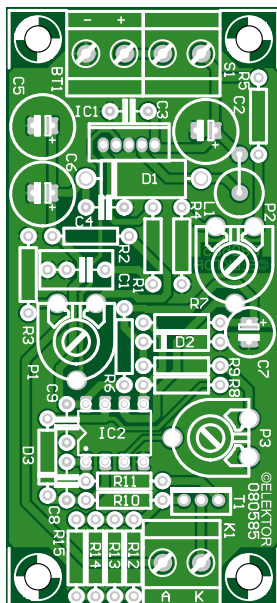
sinks. The LEDify design solves both these problems: firstly, a switching regulator reduces losses and maintains a constant light output as the battery voltage falls. Secondly, an adjustable constant current source maintains stable operating conditions for the LEDs. The LM2577T-ADJ step-up voltage regulator [1] forms the centre point of the design. Together with coil L1 and the flywheel diode D1 it boosts the input voltage from 4.8 V up to 10 to 12 V. The 4.8 V input is provided by four NiMH rechargeable batteries connected in series while the 10 to 12 V output is used to power three series connected white LEDs. One half of the



dual op amp IC2 forms an adjustable current source while the other half switches the light off when the supply voltage sinks too low to avoid discharging the cells too much. IC2A is configured to generate a constant current. Zener D2 supplies a reference 2.7 V at its cathode which is divided by the R9/P3 network to supply an adjustable voltage of 0 to 128 mV to the non-inverting input of IC2A. IC2A controls T1 so that the voltage at its inverting input, produced by the voltage drop across the resistors R12 to R15, is the same as at its non-inverting input. The adjustment range of P3 produces a current of between 0 and almost 0.5 A through the 0.25  $\Omega$  resistor formed by the four parallel 1  $\Omega$  resistors. The typical operating current of a 1-watt LED is around 350 mA, this produces a voltage of 88 mV across the four parallel resis-

tors. With the LM358 even with the input at zero there will be an output voltage of 0.6 V so with P3 at a minimum a few milliamps will still be flowing through the LEDs. The LEDs are turned off when the battery voltage falls too low, IC2B comparing a proportion of the battery voltage via P2 with the reference voltage on D2. If the battery voltage is below the reference voltage the output of IC2B will go high and the current source IC2A will be switched off. The circuit still draws a few milliamps when under-voltage is triggered so a good lower threshold to set is around 1 V per cell. With four cells P2 should be adjusted so that the LEDs switch off when the battery voltage falls below 4 V. The adjustment range on P2 produces a

voltage of around 3 V to over 10 V. Although four cells are shown in the diagram the circuit can accommodate anything from three to six. Do not use more than six cells when driving three LEDs in series, the input voltage would produce excessive dissipation in IC1 which can result in the battery voltage being applied directly to L1 and D1. The voltage step-up function of IC1 ensures that the cathode of D1 is at a higher voltage than the anode so D1 is not conducting. When the IC output switches, energy stored in L1 is converted into a higher voltage but lower current passing through D1 and then stored on capacitors C5 and C6. The 52 kHz switching frequency gives a stable output voltage with very little ripple. IC1 reads the feedback voltage measured at pin 2 and compares it with a reference



## COMPONENT LIST

### Resistors

- R1, R3 = 2k $\Omega$
- R2 = 22k $\Omega$
- R4, R5, R6 = 1k $\Omega$
- R7, R9 = 100k $\Omega$
- R8 = 3M $\Omega$
- R10 = 4k7
- R11 = 560 $\Omega$
- R12, R13, R14, R15 = 1 $\Omega$
- P1, P2 = 10k $\Omega$  preset, miniature, horizontal
- P3 = 5k $\Omega$  preset, miniature, horizontal

### Capacitors

- C1 = 330nF MKT lead pitch 5mm or 7.5mm
- C2 = 47 $\mu$ F 25V radial, lead pitch 2.5mm,  $\varnothing$  max. 8.5mm
- C3, C4, C9 = 100nF ceramic, lead pitch 5mm
- C5, C6 = 470 $\mu$ F 16V radial, lead pitch 2.5mm,  $\varnothing$  max. 8.5mm
- C7 = 10 $\mu$ F 63V radial, lead pitch 2.5mm,  $\varnothing$  max. 6.5mm
- C8 = 100pF ceramic, lead pitch 5mm

### Inductor

- L1 = 100 $\mu$ H axial, upright mounting, suggested types: 5800-101 (Bourns) rated 0.63A/0.2 $\Omega$  (Digi-Key # M8290-ND), B82111EC25 (Epcos) rated at 1A/0.65 $\Omega$  (Farnell # 9752102) or MESC-101 (Fastron) rated at 1A/0.65  $\Omega$  (Reichelt # MESC 100 $\mu$ )

### Semiconductors

- D1 = 1N5822
- D2 = 2V7 0W5 zener diode
- D3 = 1N4148
- T1 = BD139
- IC1 = LM2577T-ADJ (TO-220-5 case, straight pins)
- IC2 = LM358 (DIP-8)

### Miscellaneous

- K1, S1, BT1 = 2-way PCB terminal block, lead pitch 5mm
- S1 = single-pole on/off switch
- BT1 = holder for 4 NiMH batteries\*
- 3 pcs 1-watt power LED
- PCB # 080585-1

\* see text

of 1.23 V. It adjusts the peak switch current accordingly to maintain a constant output voltage. The divider chain formed by R2, R3 and P1 allow the output voltage to be varied between 3.5 V and 19 V. A typical 1 W LED has a forward voltage drop of around 3.25 V. Three LEDs in series gives 9.75 V, when the voltage drop across T1 and R12 to R15 are added to this we get 10 V. The adjustment range of P1 is sufficient to cater for LEDs with a forward voltage drop of up to 4.0 V.

In the Elektor lab we measured a supply current of 0.87 A from the 4.8 V battery pack giving a current through the LEDs of 0.35 A. Using 2000 mAh rechargeables you can expect a full battery pack to last for more

than two hours. The circuit efficiency is over 82 % with a 4.8 V battery pack and around 89 % with a 5.6 V battery.

The set up procedure for the completed circuit is simple. Using an adjustable power supply set the output voltage to 4.8 V. Connect three LEDs in series to the anode and cathode (A, K) contacts of K1 and adjust P1 so that the voltage measured between the A connection of K1 and ground is 12 V. Now set the current by adjusting P3 until 88 mV is measured across resistors R12 to R15. To operate the circuit at optimum efficiency reduce the 12 V supply by adjusting P1, check that a constant 88 mV is maintained across R12 to R15, if it starts to fall then you have set P1

too low. Lastly adjust P2 so that the LEDs turn off when the supply drops below 4 V. Should the LEDs not light at all check that P2 has not been set too high.

(080585-I)

## Internet Links

[1] [www.national.com/mpf/LM/LM2577.html](http://www.national.com/mpf/LM/LM2577.html)

[2] [www.elektor.com/080585](http://www.elektor.com/080585)

## Download

### PCB

080585-1 PCB design (pdf) from [www.elektor.com/080585](http://www.elektor.com/080585)