Efficient camping dimmer

By Ton Giesberts (Elektor Labs)

Especially when you're forced to be sparing with electric power, like for example when you're camping and you're depending upon the limited energy supply of your car battery to light up your little tent, it is really important to let as little energy as possible go to waste. For one, the lights don't have to be on at full force all the time. Switching lamps all the time to adjust the lighting to the situation, is just inconvenient. But if you want to dim the lights, then do it in an energy-efficient way!

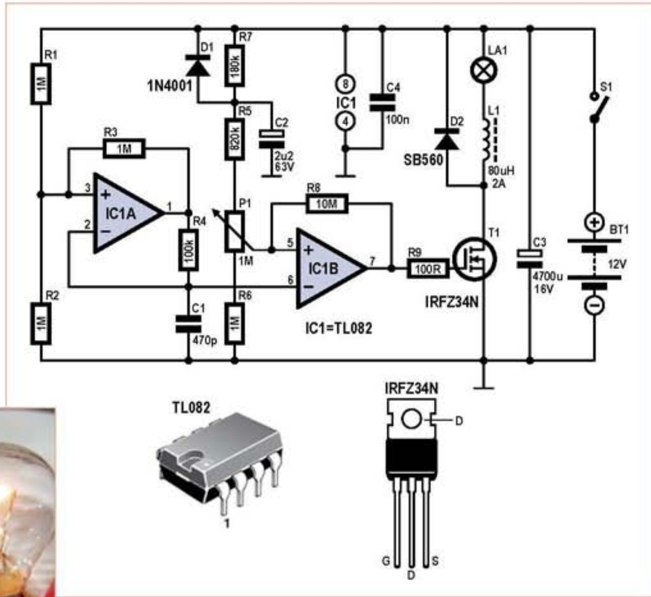
Controlling the lights at home is usually a matter of using electronic dimmer circuits. The advantage of such a dimmer is that very little energy is lost as heat in the dimmer itself. However, to regulate the brightness of a lamp that's connected to a direct current source (like a campsite or vehicle battery) these alternating current regulators aren't suitable. With a handful of parts from the junk box you can build your own efficient dimmer for use on the campsite — next year. We do want to mention: this dimmer is only suited for 12 volt incandescent light bulbs.

The principle of an energy efficient dimmer (also the alternating current type for use at home) is based on the complete turning on and off of a light bulb at a high frequency our eyes won't be able to discern. The slowness of the bulb makes extra sure that our eyes appear to perceive a steadily burning lamp instead of a flickering one. The fast turning on and off is done with an electronic switch. Theoretically no energy is lost in the switch, because when it is closed there is no electrical voltage on it and when it is open, there is no current. The product of voltage and current(= power) is therefore is always zero watts. (Usually there is some residual voltage across the switch and on top of that the switch isn't switching infinitely fast; so there is always some energy lost in the form of heat.)

If you want the bulb to burn brighter, simply increase the time the switch is closed and shorten the time it is open. That way the frequency of switching will stay the same. This relation between closed (lamp on) and open (lamp off) is called the duty cycle, or, formally, the duty factor.

In the accompanying schematic you can see the switch in the form of power MOSFET T1. This electronic switch is controlled by the part of the circuit on the left of it.

Around IC1A an oscillator was made that supplies a triangular output voltage. Sure, the shape of the triangle isn't perfect, but that doesn't matter in this particular case. This triangular voltage is compared to a reference level set on P1, by an opamp (IC1B) wired up as a comparator. If the triangular voltage level is below this reference voltage, the output of the comparator swings to 12 volts. The MOSFET will now conduct fully and lets a current flow through the lamp. If the triangular voltage rises above the reference voltage, then the voltage on output IC1B becomes zero volts, which causes the MOSFET to turn off. The current flowing through the lamp will now be interrupted. This switching goes on at an 'invisible' frequency of 12.5 kHz.



If we set a higher reference voltage with P1, a larger part of the triangular voltage will drop below this voltage and the MOSFET will therefore be conducting for a longer time (and blocking for a shorter time). The result is that the lamp burns brighter. With the given values of R5, R6, R7 and P1 a regulation of 0-100% can be achieved. Mostly because of the tolerance of P1, in reality there is a chance that 100% span can't be fully reached. If necessary, adjust the values a little and make sure that the sum of P1 and R6 roughly equals R5+R7.

In series with the lamp there is an inductor (good for at least 2 ampères) with a inductance of 80 millihenries or thereabouts, 60 or 100 is okay too. The function of this component is to limit the switch currents and to suppress the electromagnetic interference caused by the switching.

If the dimmer is switched on, capacitor C2 ensures that the brightness of the lamp will slowly increase up to the value set with P1 This will greatly improve the lifetime of your light bulb!

Just a few more practical tips: Limit the power of the lamp to about 24 watts (with a battery voltage of 12 volts the maximum current will be about 2 ampères). For switch S1 use a type that can handle at least 2 ampères and connect the circuit through a fuse (2 ampères time lag / slow-blow) to the battery just to be sure. If the lamp is dimmed to 0% the battery current will be about 4 mA; that may not be much, but shutting the dimmer off with switch S1 will save you even that bit of energy.

In our prototype (see picture) we used a preset; a potentiometer with a spindle and control knob would be way more practical of course.

To make sure that after your day out camping your car will still be able to start, the next thing you'll want to build is a battery monitor — suitable designs have been published in Elektor over the past few years, especially in the Summer Circuits editions, and of course the 30x book series.

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