INTRO - Power LED's - simplest light with constant-current circuit

Here's a really simple and inexpensive ($1) LED driver circuit. The circuit is a "constant current source", which means that it keeps the LED brightness constant no matter what power supply you use or surrounding environmental conditions you subject the LED's to.

Or to put in another way: "this is better than using a resistor": It's more consistent, more efficient, and more flexible. It's ideal for High-power LED's especially, and can be used for any number and configuration of normal or high-power LED's with any type of power supply.

As a simple project, I've built the driver circuit and connected it to a high-power LED and a power-brick, making a plug-in light. Power LED's are now around $3, so this is a very inexpensive project with many uses, and you can easily change it to use more LED's, batteries, etc.

I've got several other power-LED instructables too, check those out for other notes & ideas.

STEP 1 - What you need

Circuit parts (refer to the schematic diagram)

- R1: approximately 100k-ohm resistor (such as: Yageo CFR-25J B series)
- R3: current set resistor - see below
- Q1: small NPN transistor (such as: Fairchild 2N5088BU)
- Q2: large N-channel FET (such as: Fairchild FQP50N06L)
- LED: power LED (such as: Luxeon 1-watt white star LXHL-MWEC)

Other parts:

- Power source: I used an old "wall wart" transformer, or you could use batteries to power a single LED anything between 4 and 6 volts with enough current will be fine. that's why this circuit is convenient! you can use a wide variety of power sources and it will always light up exactly the same.

- Heat sinks: here I'm building a simple light with no heatsink at all. that limits us to about 200mA LED current. for more current you need to put the LED and Q2 on a heatsink (see my notes in other power-led instructables i've done).

- Prototyping-boards: I didn't use a proto-board initially, but I built a second one after on a proto-board, there's some photos of that at the end if you want to use a proto-board.

Selecting R3:

The circuit is a constant-current source, the value of R3 sets the current.

Calculations:

- LED current is set by R3, it is approximately equal to: 0.5 / R3
- R3 power: the power dissipated by the resistor is approximately: 0.25 / R3

I set the LED current to 225mA by using R3 of 2.2 ohms. R3 power is 0.1 watt, so a standard 1/4 watt resistor is fine.
Where to get the parts:

All the parts except the LED’s are available from http://www.digikey.com, you can search for the part numbers given. the LED’s are from Future electronics, their pricing ($3 per LED) is far better than anyone else currently.

![Image of electronic components](image1.jpg)

**STEP 2 - Specs & Function**

Here I'll explain how the circuit works, and what the maximum limits are, you can skip this if you want.

**Specifications:**

Input voltage: 2V to 18V  
Output voltage: up to 0.5V less than the input voltage (0.5V dropout)  
Current: 20 amps + with a large heatsink

**Maximum limits:**

The only real limit to the current source is Q2, and the power source used. Q2 acts as a variable resistor, stepping down the voltage from the power supply to match the need of the LED’s. so Q2 will need a heatsink if there is a high LED current or if the power source voltage is a lot higher than the LED string voltage. with a large heatsink, this circuit can handle a LOT of power.

The Q2 transistor specified will work up to about 18V power supply. If you want more, look at my Instructable on LED circuits to see how the circuit needs to change.

With no heat sinks at all, Q2 can only dissipate about 1/2 watt before getting really hot - that's enough for a 200mA current with up to 3-volt difference between power supply and LED.
Circuit function:

- Q2 is used as a variable resistor. Q2 starts out turned on by R1.

- Q1 is used as an over-current sensing switch, and R3 is the "sense resistor" or "set resistor" that triggers Q1 when too much current is flowing.

- The main current flow is through the LED's, through Q2, and through R3. When too much current flows through R3, Q1 will start to turn on, which starts turning off Q2. Turning off Q2 reduces the current through the LED's and R3. So we've created a "feedback loop", which continuously tracks the current and keeps it exactly at the set point at all times.

STEP 3 - Wire the LED
connect leads to the LED

STEP 4 - Start building the circuit!
This circuit is so simple, I'm going to build it without a circuit board. I'll just connect the leads of the parts in mid-air! But you can use a small proto-board if you want (see photos at the end for an example).

First, identify the pins on Q1 and Q2. Laying the parts in front of you with the labels up and the pins down, pin 1 is on the left and pin 3 is on the right.

Comparing to the schematic:
Q2:
G = pin 1
D = pin 2
S = pin 3
Q1:
E = pin 1
B = pin 2
C = pin 3

So: start by connecting the wire from the LED-negative to pin 2 of Q2

STEP 5 - Keep building

now we'll start connecting Q1.

first, glue Q1 upside-down to the front of Q2 so that it is easier to work with. This has the added benefit that if Q2 gets very hot, it will cause Q1 to reduce the current limit - a safety feature!

- connect pin 3 of Q1 to pin 1 of Q2.
- connect pin 2 of Q1 to pin 3 of Q2.

STEP 6 - Add a resistor

- solder one leg of resistor R1 to that dangling LED-plus wire
- solder the other leg of R1 to pin 1 of Q2.
- attach the positive wire from the battery or power source to the LED-plus wire. it probably would have been easier to do that first actually.
**STEP 7 - Add the other resistor**

- glue R3 to the side of Q2 so it stays in place.
- connect one lead of R3 to pin 3 of Q2
- connect the other lead of R3 to pin 1 of Q1

**STEP 8 - Finish the circuit!**

Now connect the negative wire from the power source to pin 1 of Q1.

You're done! we'll make it less flimsy in the next step.

**STEP 9 - Permanent-ize it**
Now test the circuit by applying power. Assuming it works, we just need to make it durable. An easy way is to put a large blob of silicone glue all over the circuit. This will make it mechanically strong and waterproof. Just glob on the silicone, and make an effort to get rid of any air bubbles. I call this method: "BLOB-TRONICS". It doesn't look like much, but it works really well and is cheap and easy. Also, tying the two wires together helps reduce strain on the wires also.

I've also added a photo of the same circuit, but on a proto-board (this one is "Capital US-1008", available at digikey), and with a 0.47-ohm R3.