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Design of a Constant Current Source

This article will explain the way a simple transistor based current source is designed, this will give an idea on how some components can be used in a practical way to make the circuit do some function, the objective is not design but to become familiar with the basic ideas.

Requirement.

We need a fixed current around **20mA** for a voltage variation of **10V to 20V** to drive a LED flasher circuit.



Component Selection.

The transistor should handle $20V * 2 = 40V$ and a current of $20mA * 5 = 100mA$. We have to overrate the components for long term reliability and make the design rugged. Chosen **MPSA92 PNP-300V-500mA** which is good for this job. Look at the pin details of **MPSA92** in the bottom view given in the right of this page in its **TO-92** package, it has a beta of **25**. The Power dissipation of **MPSA92** can be upto **650mW**, our requirement may be a max of $20V * 20mA = 400mW$ which is just within limits.

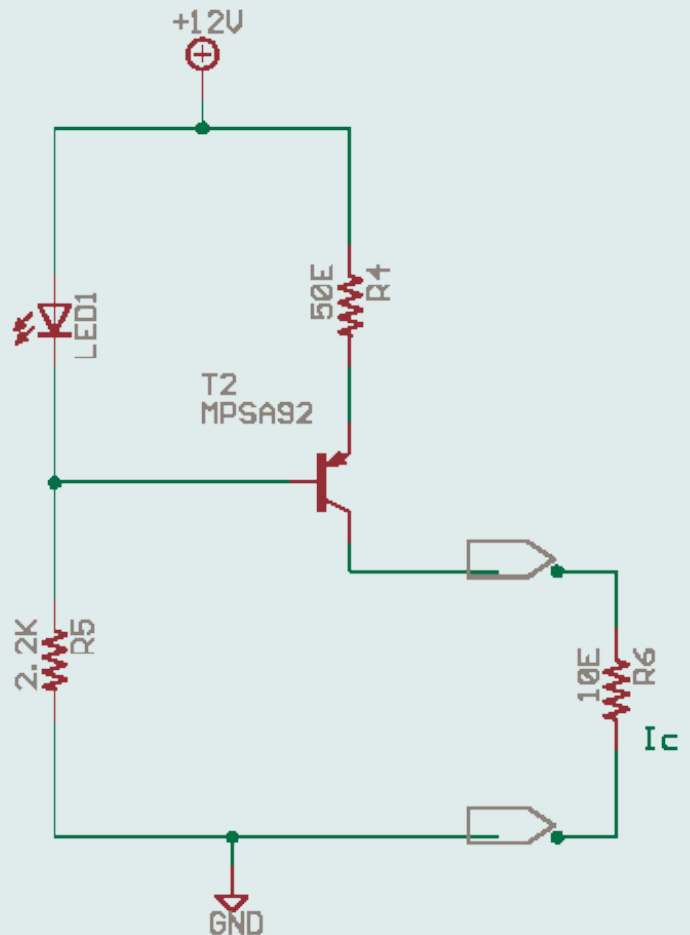
Now we need a voltage reference a low cost voltage reference is a LED which has a **1.6V** forward drop. As the circuit is a not an accurate one **CFR 5%** resistors are fine.

Circuit design.

The LED at **40mW** will last long, some energy emits as heat and some as light. $40mW / 1.6V = 25mA$. so let us choose **20mA** max LED current as a thumb rule.

MPSA92	LM336
1 2 3	1 2 3
	
1-E	1-ADJ
2-B	2-POS
3-C	3-NEG
TO-92	TO-92

Design of a Constant Current Source.



In this circuit the LED is used as a reference so to keep it cool a 2.2K is chosen. $(20V - 1.6V) / 2.2K = 8.3mA$ on the high side and when voltage is 10V the current will be 3.8mA min. .

You should know that the LED forward drop can change with ambient light as it is photo sensitive and will vary with temperature.

Look at the circuit in the right, the LED has a forward drop of 1.6V which is applied across the resistor R4 and the base-emitter diode. That means 1V across R4 as a diode drop is around 0.6V. The base-emitter now gets forward biased and a small base current I_b flows . The I_c or collector current is $1V / 50E = 20mA$. The $I_b = I_c / \beta$, That means $20mA / 25 = 0.8mA$ which flows thru R4 and R5.

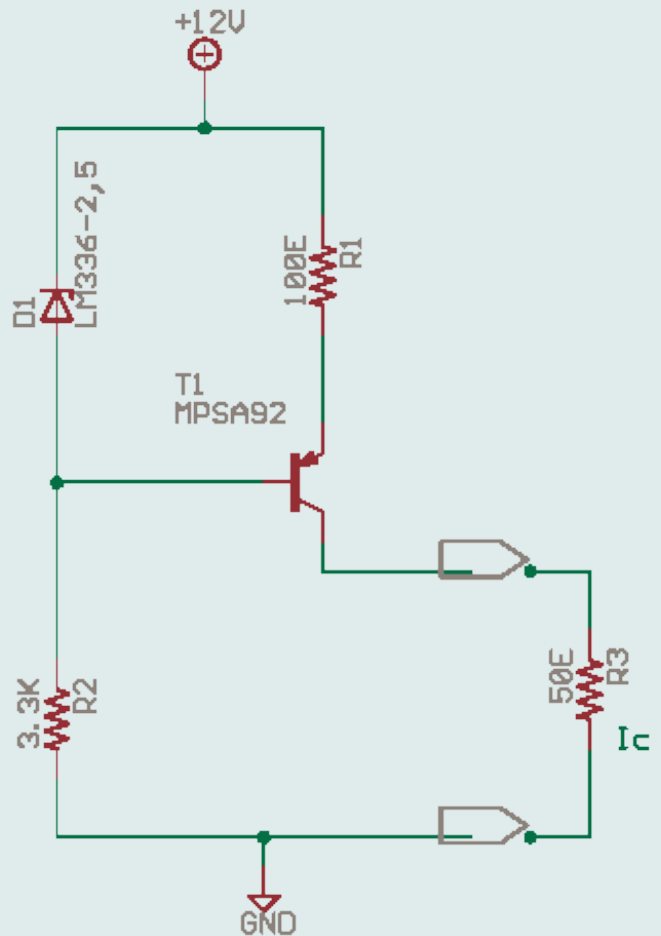
The Load Resistor R6 represents the LED flasher circuit that consumes 20mA, even on short circuit of R6 the current is limited to 20mA.

When more current flows in R6 the voltage at emitter falls, the voltage at base is $20V - 1.6V = 18.4V$, and the voltage at emitter should be $18.4 + 0.6V = 19V$ for bias and I_b to flow. When I_c increases the I_b reduces to that extent as only to maintain emitter voltage at 19V, this way I_c is kept constant, if I_c reduces the voltage at emitter builds up to rise I_b which in turn builds up I_c . so we made a current regulator.

Design of a Constant Current Source.

Circuit Improvement.

The circuit can be improved by using a zener in place of the LED or better still a temperature compensated reference like [LM336](#).



The circuit on the right will be more stable, but still the forward drop on base-emitter junction is temperature sensitive. The base current will also introduce an error, so you can get a **8 bit** stability, that means around 255 counts on an A-D converter. If you need a more stable current source you should design with FET and opamps.

[LM336-2.5 pdf](#) details, It has a **2.5V** drop. A [LM336-5.0 pdf](#) version is also available for **5V**. these are from [National Semiconductor](#).

Operating Current of LM336 is **400uA to 10mA**, 20V The max. voltage $20V / 3.3K = 6mA$. so within limits. Then you can compute the rest, wire it up to see if your design works.

"If all parts are working, connected in proper polarities and there are no dry solders and loose connections then any circuit well designed ought to work."

– Solderman 1702




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