Simple Voltage Regulators and Switching Transistors

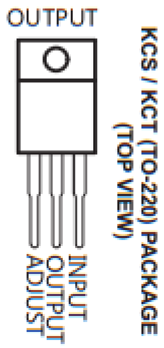

Figure 1 Pinout of LM317 in its TO-220 format from Texas Instrument (TI) LM317 datasheet.

Simple Voltage Regulator—The LM317

The LM 317 is a simple, reliable and inefficient device for doing DC->DC conversion. It is a voltage regulator, it accepts voltage at one value (INPUT) and passes voltage at a lower value (OUTPUT). The difference between these voltages happens inside the device. In this experiment you will construct a simple voltage regulating circuit and measure its power efficiency.

The LM317 has 3 pins, Input, Output, and Adjust that are, quite sensibly, for the input power, the output power, and adjusting the output voltage leaving the regulator.

An example of its use drawn from its data sheet is:

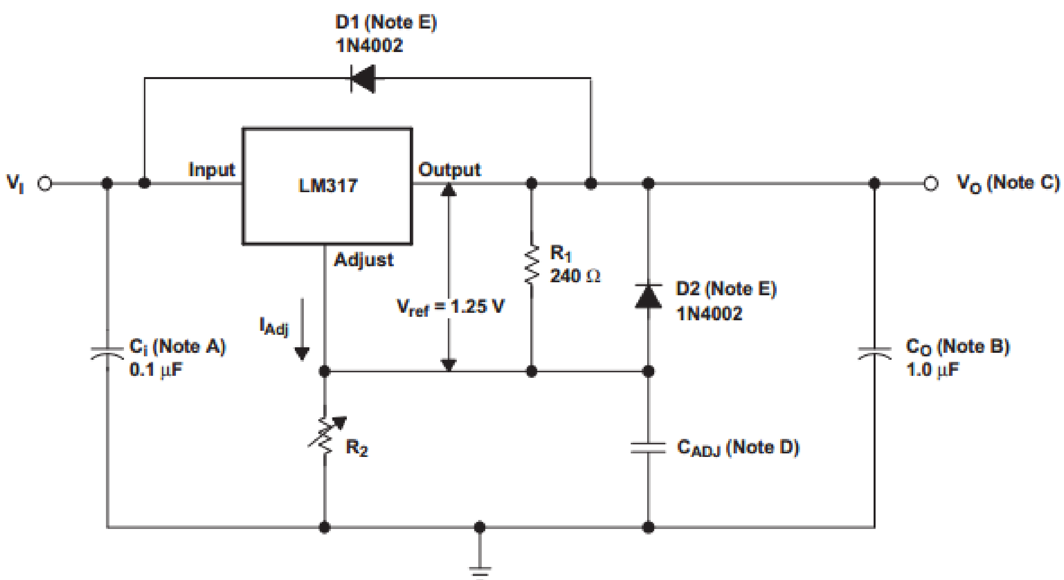

Figure 2: From TI LM317 datasheet. See data sheet for notes.

Using the equation from page 7 of the datasheet, calculate the expected output voltage, Vo, for R1=220Ω and R2=1kΩ, and record it here. ____________

Construct a circuit using the sketch you brought to class (it should be simpler than the one shown in Fig. 2) using

- 220Ω between the Adjust and Output pins,
- 1kΩ between adjust and ground.

Once you have completed the circuit power it with 20VDC. Measure the output voltage for an infinite load resistance (open circuit) and record it here.___________

Now that you have a functioning circuit, measure the power efficiency of the circuit as a function of load resistance. You should use the following resistances:

100kΩ, 30kΩ, 10kΩ, 3kΩ, 1kΩ, 300Ω, 100Ω, 30Ω.

As the regulator regulates voltage, it is only the current that should change. I recommend using a hand held multi-meter for all your current measurements.

What is dissipating the bulk of the wasted energy? What direct observation (using no meters) is your evidence for this? This will be much more apparent at low load resistance.

Include a graph of power efficiency vs load with useful scales.

Switching Transistors

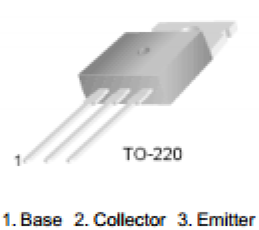

Figure 3 TIP31 BPJ transistor, image from data sheet.

We will soon be making extensive use of transistors as switch on and off significant currents to do power conversion. Before we start doing pulse width modulation (PWM) we will review using a transistor to switch on and off a useful load (a motor) using a gating signal. We will be comparing two switching transistors, BPJ and a MOSFET. The TIP31 (transistor in plastic) is an NPN type BPJ power transistor. It is capable of switching 40V and 3Amps. It is SI based and so switches for a base-emitter voltage of around 0.7V. They are very cheap (~$0.20) if you buy them in the right places.

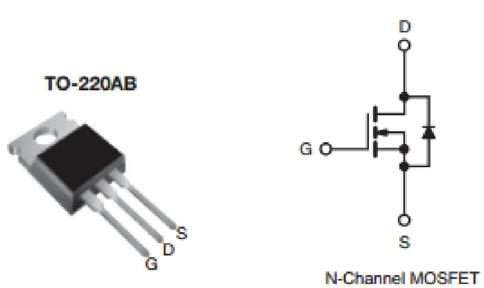

Figure 4 IRZ34N Mosfet transistor, image from datasheet

The other transistor is a IRFZ34N, an N-Channel enhanced mode MOSFET transistor that is off by default and has a built-in freewheel diode.

It can handle significantly more powerful, it can switch 55V at 29Amps, with a maximum power dissipation of 68W. The switching voltage for these MOSFETS is ~2V. They are still relatively cheap ($0.70) but not as cheap as the BPJs.

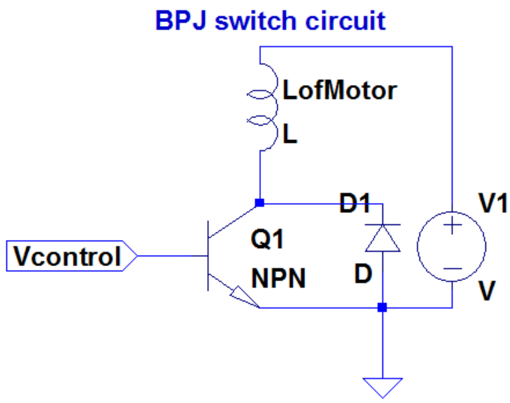

Figure 5 motor controlled using a BJP transistor as a switch.

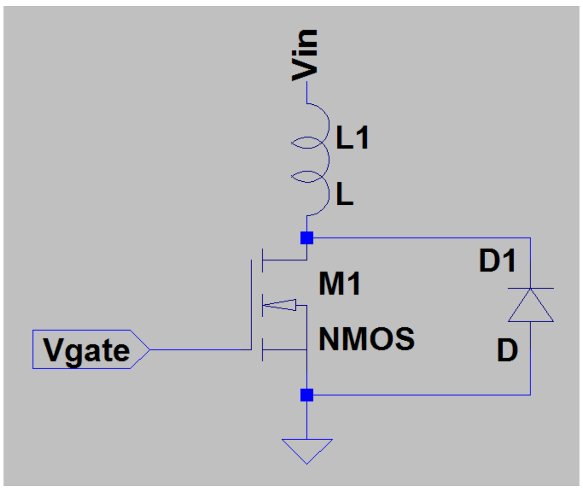

Figure 6: MOSFET switch.

We will be using these transistors to control a motor, a load with a significant current draw. We will be using the transistor to open and close the path to ground. This arrangement is the simplest method as the control ground (connected to the transistor emitter/source) and the power ground have the same voltage. This is shown in Fig. 5 using a BPJ transistor and in Fig. 6 using a MOSFET.

The diode is necessary with both transistor circuits in both because of the inductive load. When the motor is suddenly turned off there is a large di/dt which causes a large back potential to form. The diode provides a path for current to flow backwards through the motor, if it didn't the transistors would be very likely to blow. This is more of a danger for a MOSFET, enough of a danger that this package has the reversed diode built into it.

Instructions:

Construct the circuits shown in Figs. 5 and 6. Draw power for the motor (Vin) from the 5 V (fixed), 3 Amp (max) DC power supply terminals. Control the transistor using the DC power supply's variable output terminal.

For both transistors measure the power consumed by the motor and the power expended to keep the transistor in the conducting state (motor on).

Motor Voltage___________________ and current______________________

Power consumed by motor in BPJ circuit _____________.

V_{be} ___________________ and I_b______________________

Power consumed by BPJ from control circuit to keep motor on _________________ .

Motor Voltage___________________ and current______________________

Power consumed by motor in MOSFET circuit ____________.

V_{gs} ___________________ and I_g______________________

Power consumed by MOSFET from control circuit to keep motor on __________________.