

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

6.101 Introductory Analog Circuits Laboratory

Spring 2020 Problem Set #3

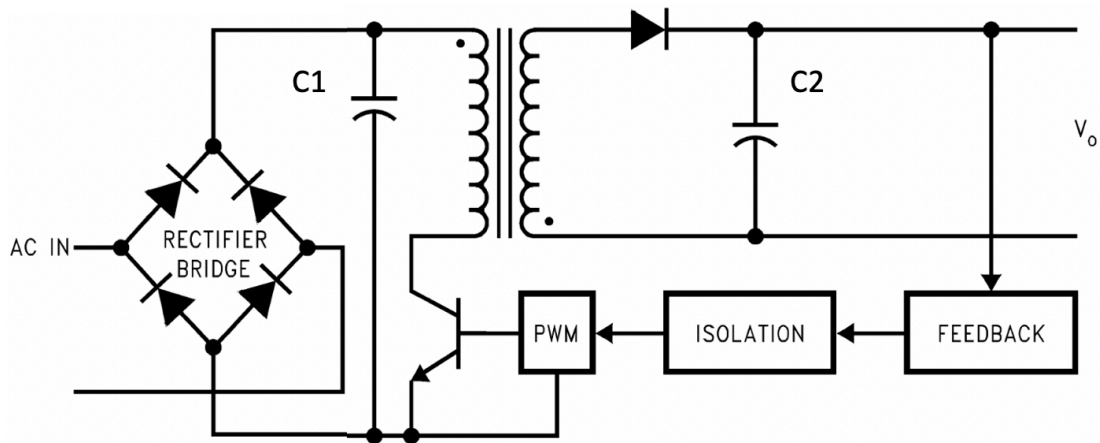
Due: Tue, 03/03/2020 2:30p

Read Sections (Neamen)

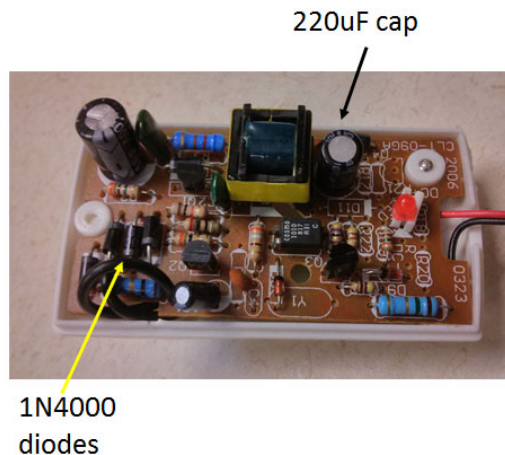
∞ 5.1-5.4 BJT Circuits

Problems:

1. (3 points) Small efficient power supplies, for example smart phone/USB chargers, rectify AC on the primary side and use pulse width modulation (PWM) typically 10-125kHz to create the 5V output. The higher frequency allows for a much smaller transformer vs a 60 Hz transformer. Feedback to the primary side is achieved with a photoisolator. The following is a simplified block diagram of a typical power supply using flyback design¹.



Here is a photo of a typically USB charger.



¹ <http://www.ti.com/lit/an/snva006b/snva006b.pdf>

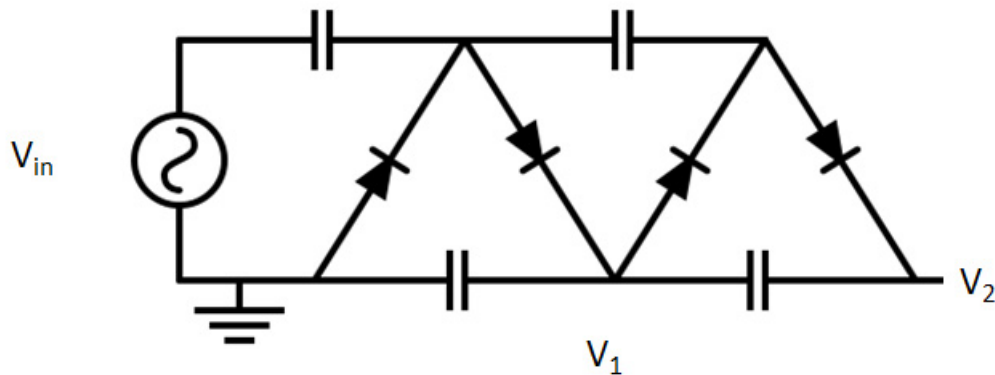
For the specification of the charger pictured above (input: 110-240VAC, output: 5v @650ma) what is the minimum peak inverse voltage (PIV) rating for the bridge diodes ?

Which 1N4000 series diode will meet that specification?

What is voltage rating required for C1?

C2 is a 220uF capacitor. The ripple on the output at **250** ma is 100mv, typical for an inexpensive charger. What is the frequency of the PWM circuit assuming a 10% duty cycle? [You may make simplifying assumptions.]

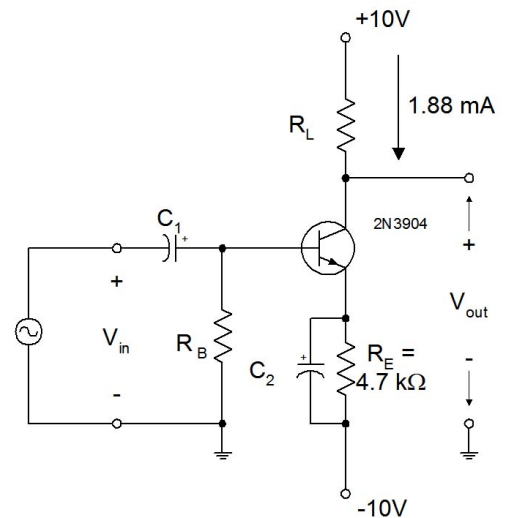
2. (2 points) Neamen 5.42 p 361 (pnp configuration)
3. (2 points) The circuit below is a 2 stage Cockcroft-Walton voltage multiplier. Each stage consists of 2 capacitors and 2 diodes. (This circuit will be used in a future lab.) John Cockcroft and Ernest Walton, designed this circuit in 1932 to generate high voltages for a particle accelerator. The number of stages can be extended to get higher voltages.



Assuming V_{in} is a -2v to +2v peak to peak 100MHz sine wave. The capacitors are 100nf and the diodes are 1N5711 Schottky diodes with a 0.2v drop. The load resistor (not shown) is high and can be ignored. What is V_1 and V_2 ?

(over)

4. (2017 Quiz – 3 points) The amplifier on the right has dual supplies, which simplifies biasing greatly, since there is only one biasing resistor, thus R_B and V_B are readily apparent. The rule of thumb for choosing R_B is the same as for a single supply circuit. Assume that $V_{BE} = 0.7 \text{ V}$. Assume C_2 is a short circuit at all frequencies of interest.



3a. Given that $\beta_F = 200$ what is the DC base current I_B of the transistor? _____

3b. What value is required for R_B for bias stability? _____ $\text{k}\Omega$

3c. What value of R_L is required to provide equal voltage drops across R_L and V_{CE} ? _____ $\text{k}\Omega$

3d. What are the values of g_m and r_π for this transistor at the given bias current? g_m _____ r_π _____

3e. What is the DC input resistance to this transistor amplifier, looking into the base (ignoring the effect of R_B)? _____