ECE 320 - Homework #5 Solution

DC to DC Converters, Transistors, Transistor Switch. Due Monday, September 25th, 2017

Full Bridge Rectifier

1) For the following circuit, determine the

- DC voltage (i.e. the mean voltage), and the
- AC voltage (peak-to-peak or ripple)

at V1 and V2.

Max(V1) = 18.6V

20V peak, minus two diodes

Assume V2 = 18.6V. The current is

$$I = \left(\frac{18.6V - 3V}{1k}\right) = 15.6mA$$

The ripple is

$$I = C\frac{dV}{dt}$$

$$15.6mA = 100\mu F \cdot \frac{dt}{1/120s}$$

$$dV_1 = 1.3V_{pp}$$

So, the voltage at V1 is

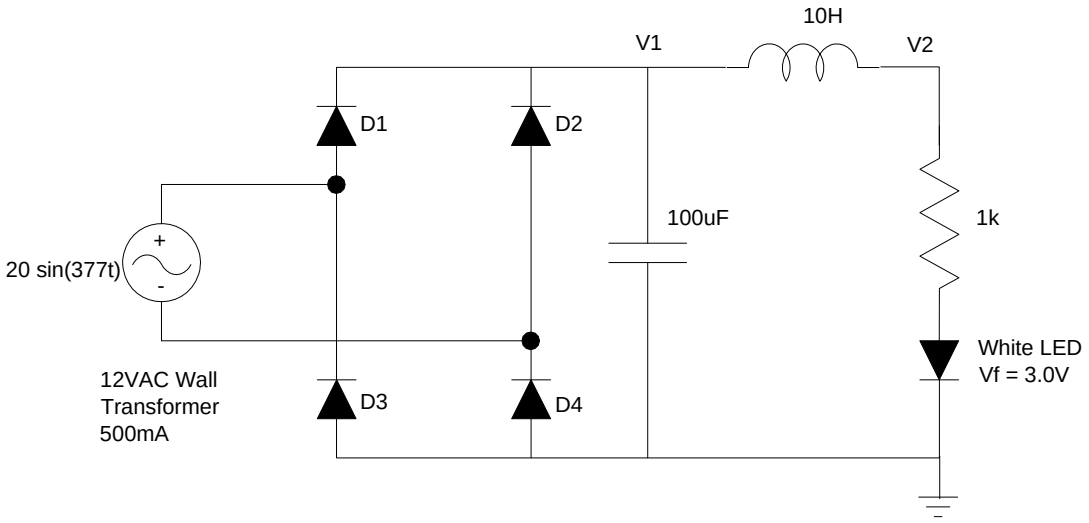
- max(V1) = 18.6V
- min(V1) = 17.3V
- mean(V1) = 17.95V

The voltage at V2 is then

- mean(V2) = 17.95V (same as V1)

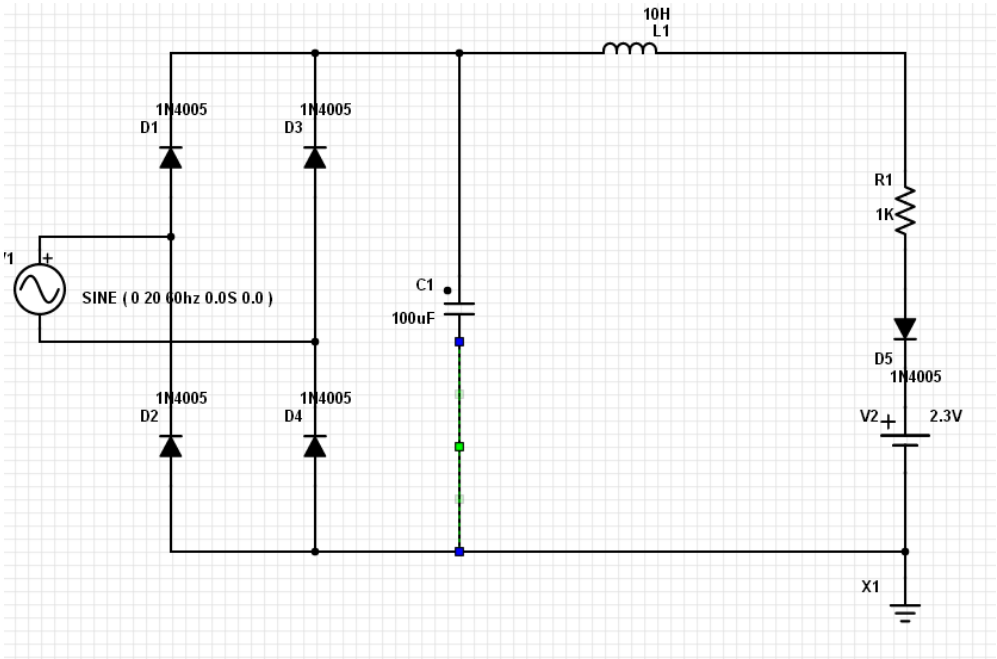
$$V_{2pp} = \left|\frac{1000}{1000 + j7540}\right| \cdot V_{1pp}$$

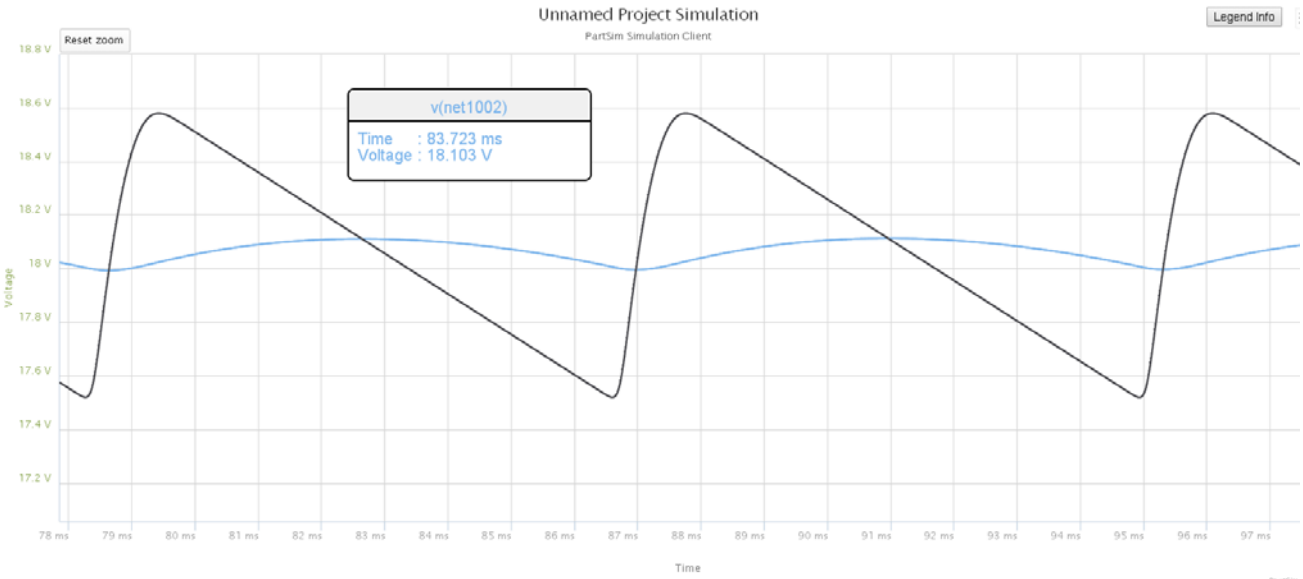
$$V_{2pp} = 171mV_{pp}$$



2) Check your analysis in PartSim.

	V1		V2	
	Calc	Sim	Calc	Sim
max	18.6V	18.58 V		18.11V
min	17.3V	17.519 V		17.995V
mean (DC)	17.95V	18.05V	17.95V	18.05V
Vpp (AC)	1.3Vpp	1.06Vpp	171mVpp	115mVpp





Lab:

3) Check your analysis in lab.

Transistors:

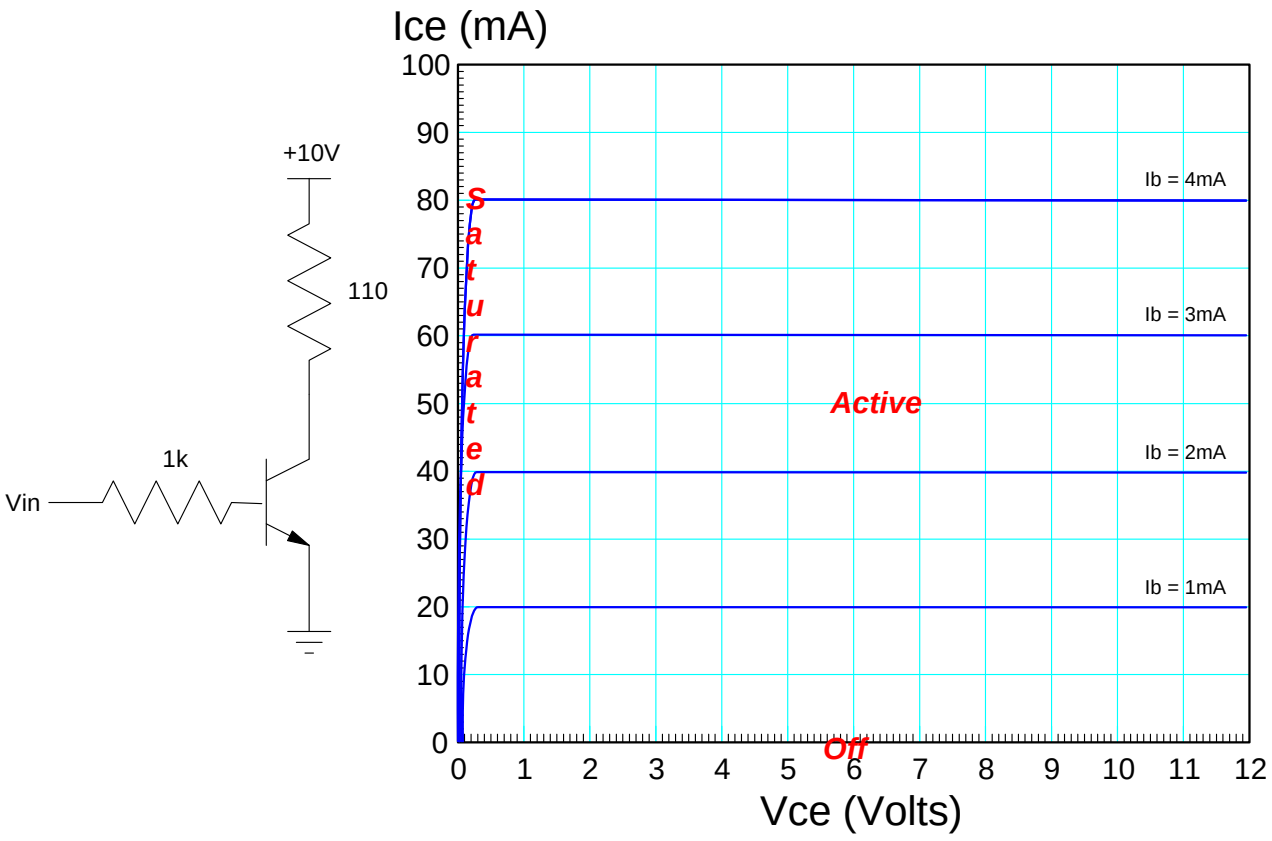
The VI characteristics for a transistor are shown on shown below

4) Determine the gain for this transistor and label the following regions

- Off
- Active
- Saturated

Gain = 20

4mA -> 80mA



5) Draw the load line for the following circuit and mark the operating point when

a) Vin = 0V

Ib = 0, Ic = 0, Vce = 10V

b) Vin = 2V

$$I_b = \left(\frac{2-0.7}{1k}\right) = 1.3mA$$

$$I_c = \beta I_b = 26mA$$

$$V_{ce} = 10V - 110\Omega \cdot 26mA = 7.14V$$

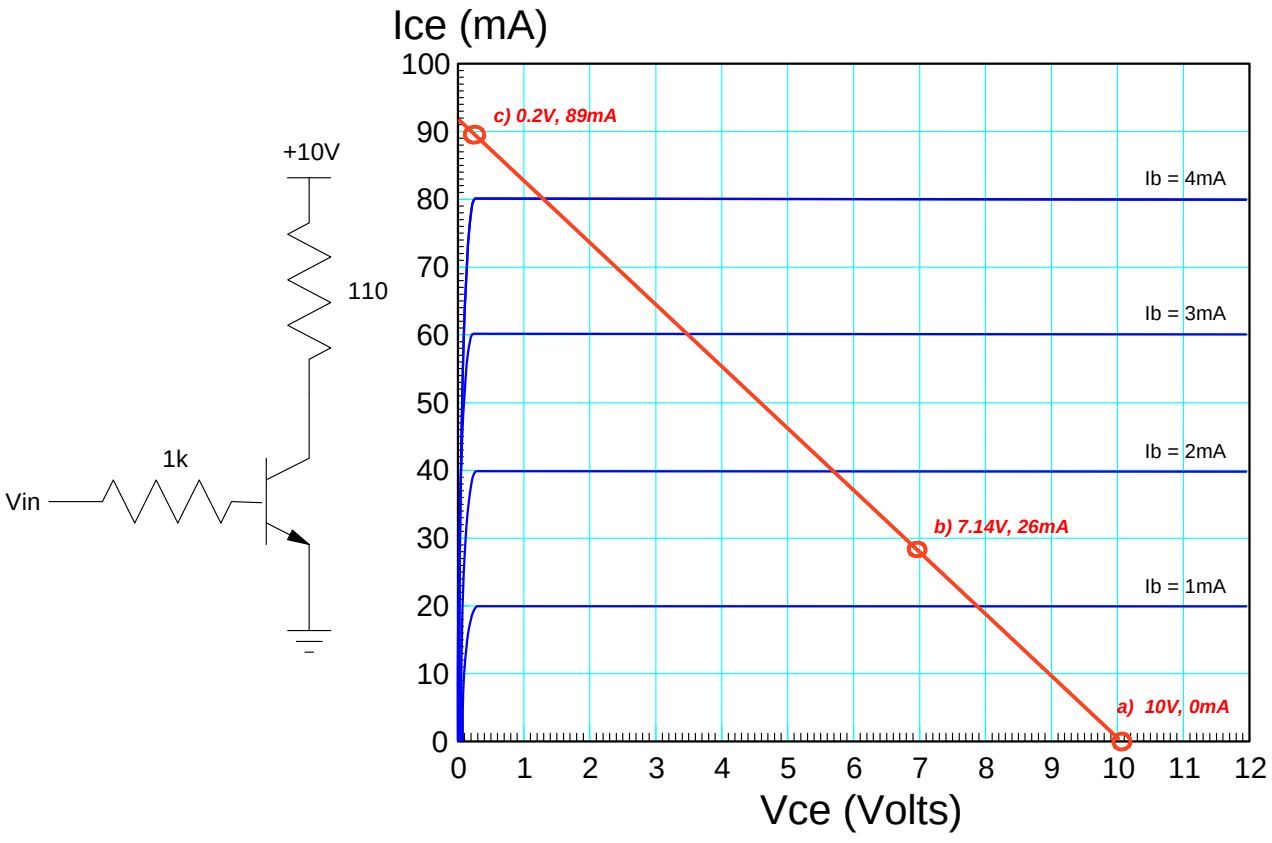
c) Vin = 10V

$$I_b = \left(\frac{10-0.7}{1k}\right) = 9.3mA$$

$$\beta I_b = 186mA > 91mA \qquad \text{(saturated)}$$

$$V_{ce} = 0.2V$$

$$I_c = \max(I_c) = \left(\frac{10V-0.2V}{110\Omega}\right) = 89mA$$



Transistor Switch

Assume a 3904 NPN transistor with the following specifications (available in room 211)

- Vbe = 0.7V Vce(sat) = 0.2V max(Ic) = 200mA β=200

6) Design a circuit to meet the following requirements:

- Input: 0V or 5V DC, capable of up to 20mA
- Output: 5V DC Motor which draws at most 200mA
- Relationship:
  - 0V in results in 0V across the motor, +/- 0.5V
  - 5V in results in 5V across the motor, +/- 0.5V

To drive the motor, connect it between 5V and ground. This draws at most 200mA.

Break the path to ground with a transistor. Choose the resistor, Rb, so that the transistor turns

- Off when Vin = 0V
- Saturated when Vin = 5V

Off: Easy. Vin = 0 sets Ib = 0 turning off the transistor

Saturated:

$$\beta I_b > I_c$$

$$I_b > \frac{200mA}{200} = 1mA$$

Let Ib = 2mA

$$R_b = \left(\frac{5V - 0.7V}{2mA}\right) = 2150\Omega$$