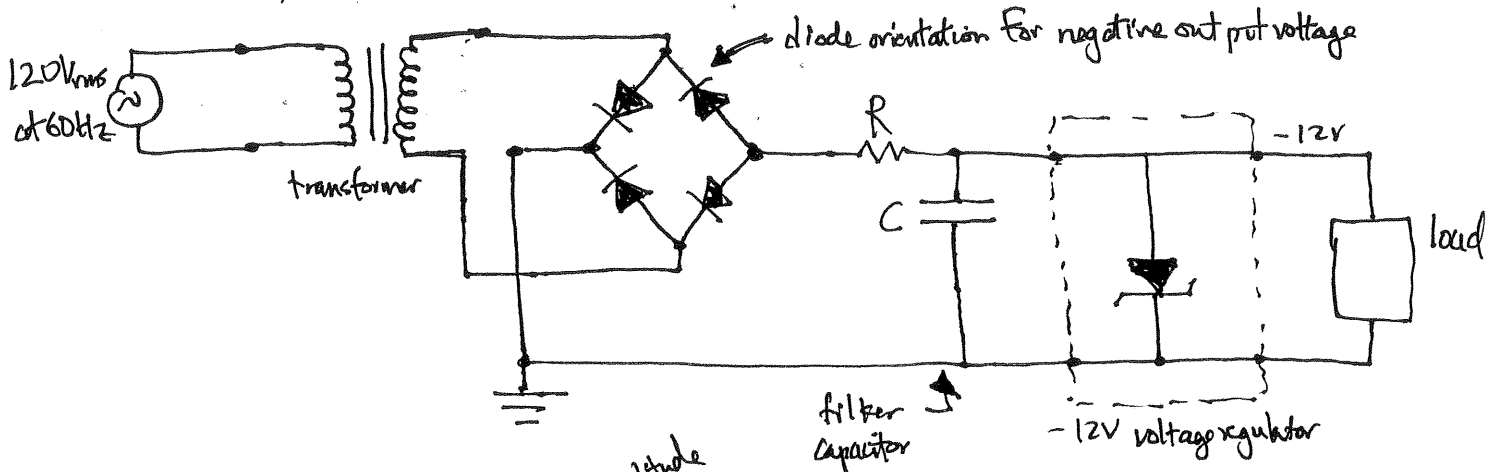


Simpson Ch.4: 23, 25, 26, 28, Ch.5: 8, 10, 11, 12

Simpson, chapter 4:

[23] Sketch a full-wave rectifier circuit to produce a -12V DC output.



- This ~~input~~ <sup>amplitude</sup> primary voltage on the transformer is  $V_p \approx 120V \cdot \sqrt{2} = 170V$   
 We want the secondary to be  $V_s \geq 12V + 2 \times 0.6V = \underline{13.2V}$

Since there are two forward-biased diodes between output and ground in each half cycle.

So... the turns ratio on the transformer should be about...

$$\frac{N_s}{N_p} > \frac{13.2}{170} = 0.0776 \quad \text{or...} \quad \frac{N_p}{N_s} \lesssim 12.9$$

Choose  $\boxed{\frac{N_p}{N_s} = 12}$  or  $\frac{N_s}{N_p} = 0.0833$

- The filter capacitor has to be big enough to reduce the ripple to acceptable levels under load conditions. If, for example, we want to draw 100mA, then in  $\frac{1}{120Hz} = 8.3ms$  (the ~~time~~ period of the ripple), the voltage on the filter capacitor will decrease by approximately...

$$\Delta V = \frac{I_{load} \Delta t}{C}$$

For the ripple to be less than 5% of the DC output level under loaded conditions... we need  $C > \frac{I_{load} \Delta t}{0.05 V_{oc}} = \frac{0.1A \cdot \frac{1}{120}}{0.05 \cdot 12V} = \underline{1.4 \times 10^{-3} F}$

- The filter resistor R should be small so the DC output does not droop, under loaded conditions

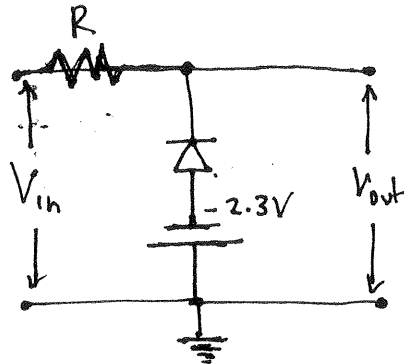
$$V_{out} = \frac{R_{load}}{R + R_{load}} \cdot V_{in}$$

If  $\frac{V_{out}}{V_{in}} = 0.95$ , then...  $\frac{R}{R_{load}} + 1 \leq \frac{1}{0.95}$  or  $R < 0.053 R_{load} = 0.053 \cdot \frac{12V}{0.1A} = \underline{6.3 \Omega}$

$\boxed{14,000 \mu F}$

25

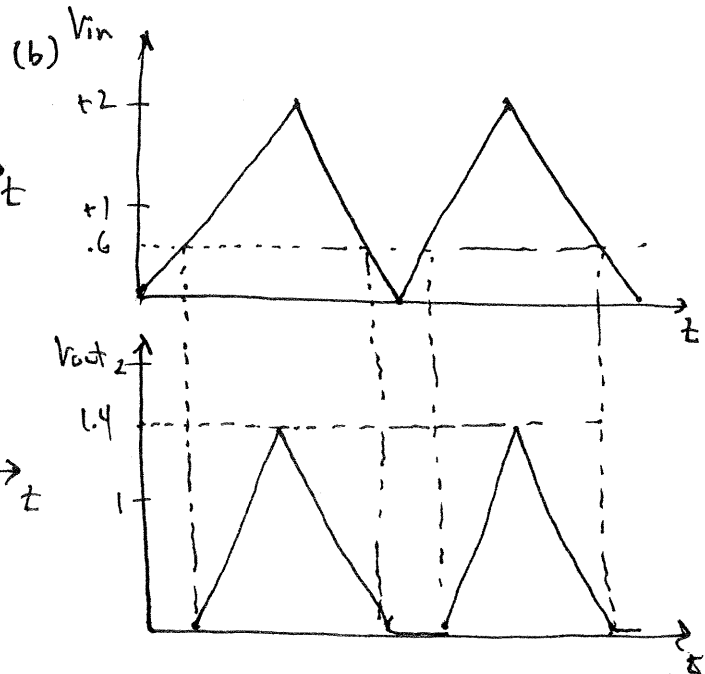
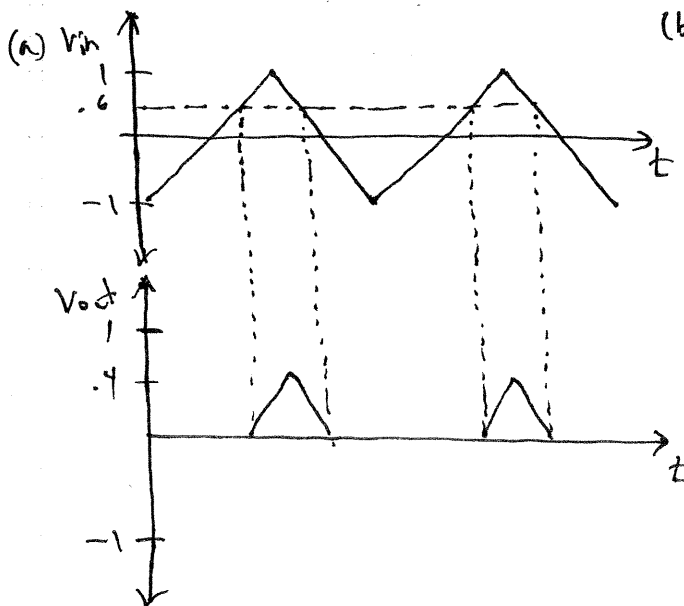
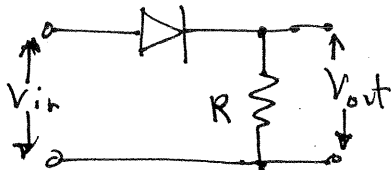
Diode clipping circuit to clip off negative-going pulses at  $-3.0\text{V}$ .



When the input goes more negative than  $-3.0\text{V}$ , the diode is forward-biased and current flows so that the portion of  $V_{in}$  that is more negative than  $-3\text{V}$  appears across the resistor  $R$ , and not across the output.

26

Sketch the output voltage, ~~for~~ for the following circuit and input waveforms.



28

Explain why the ripple amplitude in a power supply increases as the load current drawn from it is increased.

Two views of this effect:

1) The load current depletes charge from the filter capacitor between the peaks in the output from the rectifier. Since the voltage across the filter capacitor is  $V = Q/C$ , if a larger load current is drawn, then the voltage drops more than would be the case for a smaller load current. Recall that  $\int I dt = Q$ . This can be approximated as...

$$\Delta V_{\text{ripple}} = \frac{I_{\text{load}} \cdot \Delta t_{\text{ripple}}}{C} \quad \text{where } \Delta t_{\text{ripple}} = \frac{1}{f_{\text{ripple}}} = \frac{1}{120 \text{ Hz}} = 8.3 \text{ ms}$$

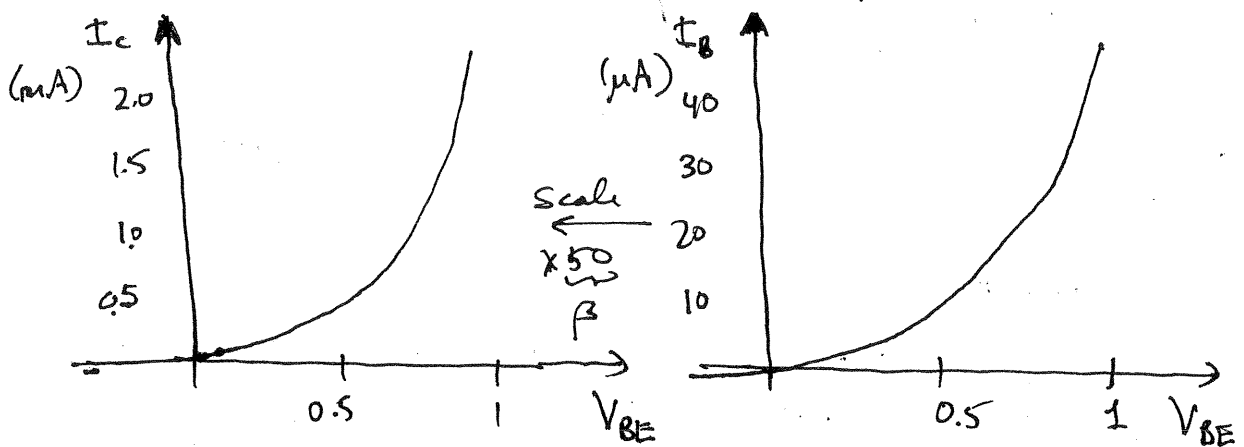
for full-wave rectification.

2) A larger load current corresponds, for fixed output voltage, to a smaller load resistor. The RC discharge time for the low-pass filtered output is therefore shorter...

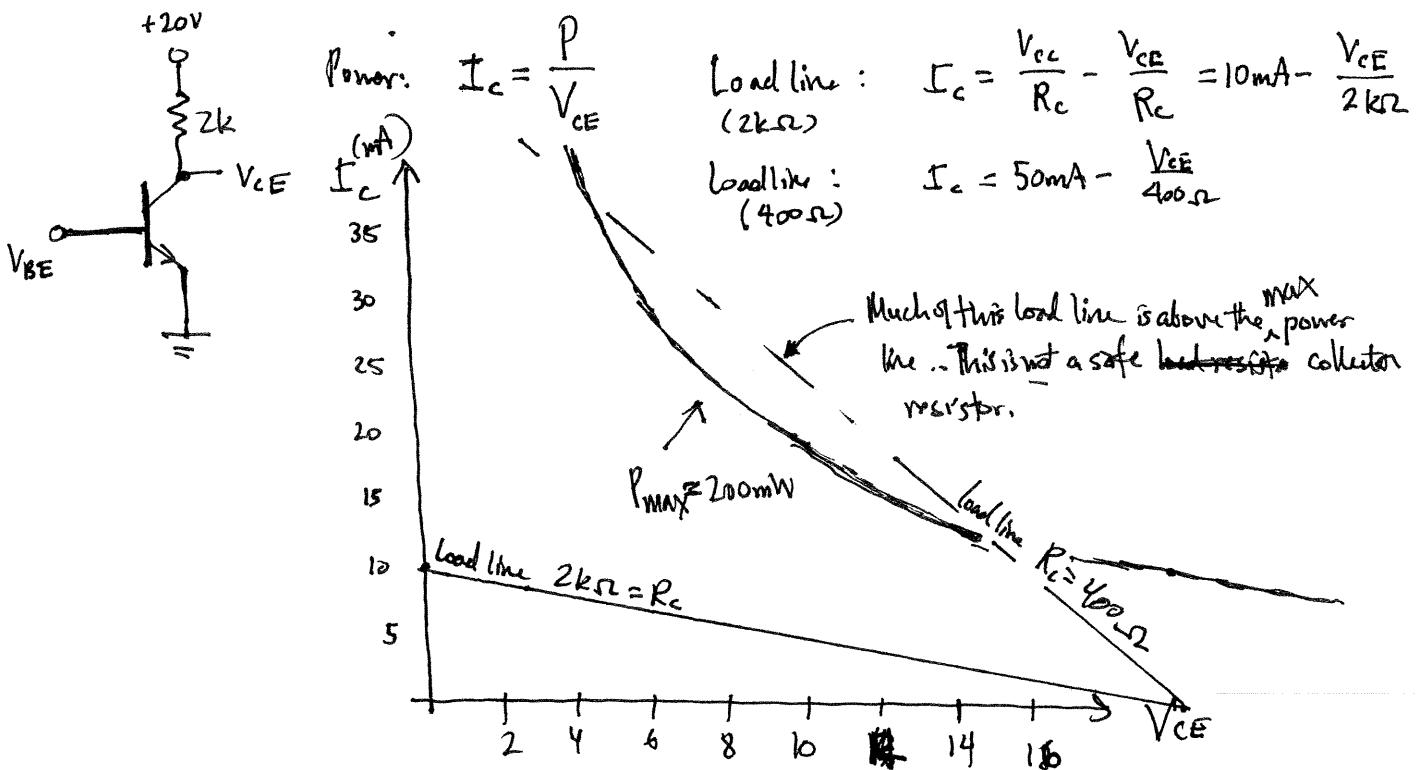
Simpson, chapter 5 :

8 Sketch a graph of collector current vs. base-emitter voltage for a silicon transistor. Repeat for base current vs. base-emitter voltage. Use  $\beta = 50$ .

The base-emitter is a pn junction ... so  $I_B$  vs.  $V_{BE}$  looks like a diode. And the transistor maintains (approximately)  $I_C = \beta I_B$  so...

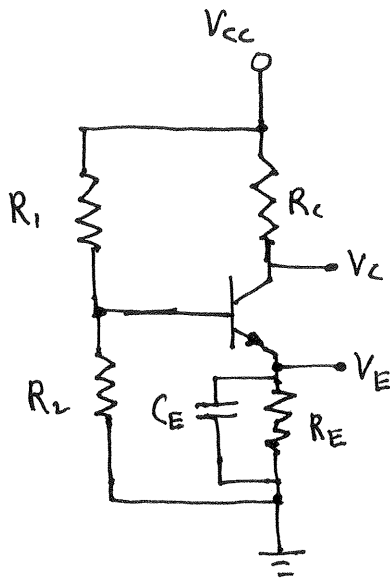


10 Consider a transistor with  $P_{max} = 200mW$  and a 20V power supply. Plot the max power curve on a graph of  $I_C$  vs.  $V_{CE}$ . Also draw the load line for a  $2k\Omega$  collector resistor.



11

Calculate  $I_c$  and  $V_{CE}$ . The transistor has a  $\beta$  of 100.



• The bypass capacitor on the emitter does not affect the DC quiescent operation of the transistor

• Base voltage is output of a voltage divider

$$V_B = \frac{R_2}{R_1 + R_2} \cdot V_{CC} = \frac{1}{5} \cdot 15V = \underline{\underline{3.0V}}$$

• Emitter is one forward-biased diode drop lower than this

$$V_E = V_B - 0.7V = \underline{\underline{2.3V}}$$

• The current through the emitter resistor is therefore  $I_E = \frac{V_E}{R_E} = \frac{2.3V}{1k\Omega} = \underline{\underline{2.3mA}}$

• The collector current is approximately equal to the emitter current when  $\beta \gg 1$ .

$$\boxed{I_c \approx 2.3mA}$$

• The collector voltage is  $V_c = V_{CC} - I_c R_c = 15V - 2.3mA \cdot 2k\Omega = 15V - 4.6V$

$$V_c = 11.4V$$

• So the collector-to-emitter voltage is..

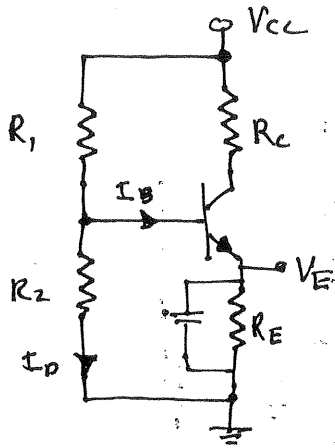
$$V_{CE} = V_c - V_E = 11.4V - 2.3V = \boxed{9.1V}$$

• Check to see that  $I_B$  is much less than current in  $R_2$  .. otherwise voltage divider is loaded down...

$$I_B \approx \frac{I_c}{\beta} \approx 23\mu A$$

and  $I_2 = \frac{V_B}{R_2} = \frac{3.0V}{10k\Omega} = \underline{\underline{333\mu A}}$  much greater... check ✓

- 12 Calculate  $R_1$  and  $R_2$  if  $I_D = 20 I_B$ . The transistor is silicon and has a  $\beta = 100$ .  $V_E = 1V$ .



- Knowing that the emitter voltage is  $1V$ , we can find the emitter current.

$$I_E = \frac{V_E}{R_E} = \frac{1V}{500\Omega} = \underline{\underline{2.0\text{ mA}}}$$

- Since  $\beta \gg 1$   $I_C \approx I_E = 2.0\text{ mA}$

- The base current is, therefore,  $I_B = \frac{I_C}{\beta} \approx \underline{\underline{20\mu\text{A}}}$

- The base voltage is  $V_B = V_E + 0.7V = \underline{\underline{1.7V}}$

- The current  $I_D$ , in resistor  $R_2$  is  $I_D = V_B / R_2$  and we want this to be 20x larger than  $I_B$ ... so...

$$R_2 = \frac{1.7V}{400\mu\text{A}} = \underline{\underline{4.25\text{ k}\Omega}}$$

- To get  $V_B = 1.7V$  from the voltage divider formed from  $R_1$  and  $R_2$ , ...

$$V_B = \frac{R_2}{R_1 + R_2} \cdot V_{CC} \quad \text{solve for } R_1 \dots$$

$$\frac{R_1 + R_2}{R_2} = \frac{V_{CC}}{V_B} \quad \text{or} \quad \frac{R_1}{R_2} + 1 = \frac{V_{CC}}{V_B}$$

$$\text{or... } R_1 = R_2 \left[ \frac{V_{CC}}{V_B} - 1 \right] = 4.25\text{ k}\Omega \left[ \frac{15V}{1.7V} - 1 \right] = \underline{\underline{33.25\text{ k}\Omega}}$$