EE 322 Analog Electronics, Spring 2010
Exam 1 February 24, 2010
solution

Rules: This is a open book test. You may use the textbook as well as your notes. The exam will last 50 minutes. Each problem counts equally toward your grade.

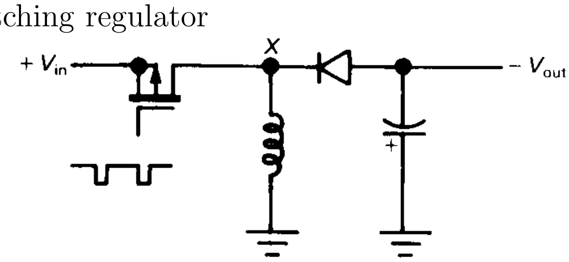
1. **Switching regulator**

   (a) **Draw a inverting switching regulator**

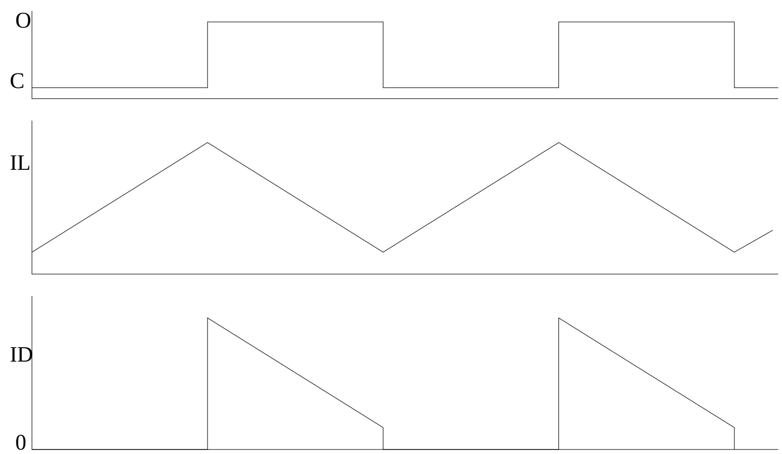
   (b) **Carefully sketch the switch state, the current through the diode and the current through the inductor for continuous mode using any voltage ratio you like (you don't need to specify the voltage ratio).**

   (c) **Same, but for discontinuous mode, using the same voltage ratio as in the previous question.**

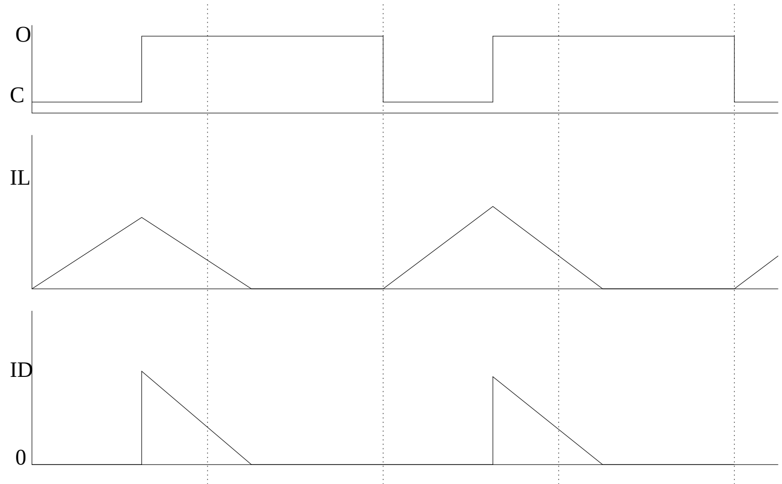
   (a) Inverting switching regulator



   (b) Continuous mode



   (c) Discontinuous mode



2. Linear regulator

(a) Design a 5 volt regulator with outboard power transistor using the 723.

(b) Add a current sense resistor to limit the current to 1 A.

(c) Add a foldback circuit to make the short-circuit current 0.5 A. (For speed, you may assume the current sense resistor does not change from the previous question, if you like)

(a) Divide the supplied reference voltage 7.15 V according to a voltage divider $R_2/(R_1+R_2)$,

$$\frac{R_2}{R_1+R_2} = \frac{5}{7.15}$$

$$R_2 = 0.7R_1 + 0.7R_2$$

$$0.7R_1 = 0.3R_2$$

$$R_2 = 0.43\,R_1$$

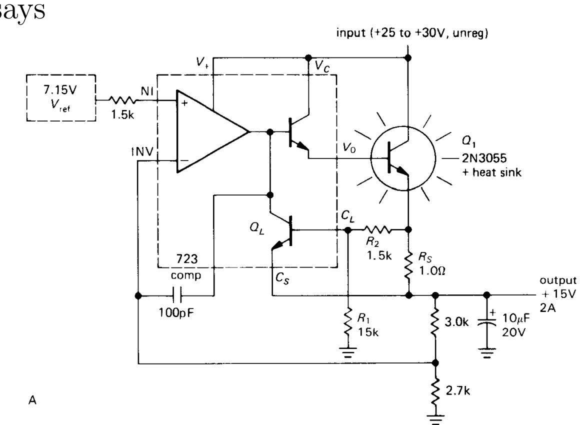
Choose $R_1 = 1\,\mathrm{k}\Omega$, and $R_2 = 430\,\Omega$.

(b) We want the BJT to activate when $V_{BE} = 0.5\,\mathrm{A}$, so

$$I_{\max} R_S = V_{BE,on}$$

$$R_S = \frac{V_{BE,on}}{I_{\max}} = \frac{0.5}{1} = 0.5\,\Omega$$

(c) Let's assume that R_S stays the same. In that case we use the formula from the book which says



$$\frac{I_{\text{max}}}{I_{\text{SC}}} = 1 + \left(\frac{R_2}{R_1 + R_2}\right)\frac{V_{\text{reg}}}{V_{BE,on}}$$

$$\frac{R_2}{R_1 + R_2} = \left(\frac{I_{\text{max}}}{I_{SC}} - 1\right)\frac{V_{BE,on}}{V_{\text{reg}}} = \left(\frac{1}{0.5} - 1\right)\frac{0.5}{5} = 0.1$$

$$R_2 = 0.1R_1 + 0.1R_2$$

$$0.9R_2 = 0.1R_1$$

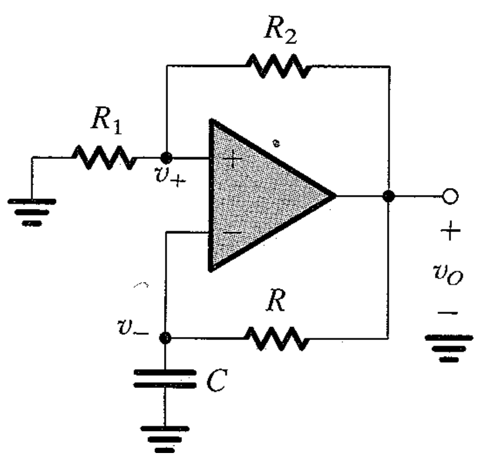
$$R_2 = 0.11R_1$$

Choose $R_1 = 2\,\text{k}\Omega$, and $R_2 = 220\,\Omega$.

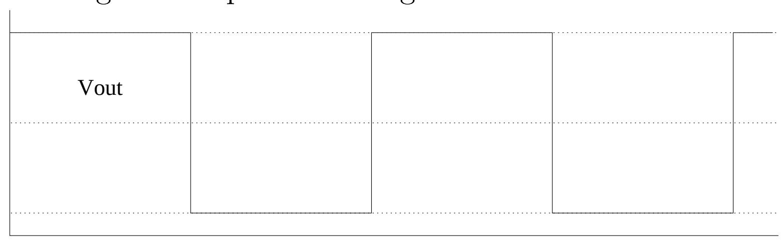
3. Consider the following astable circuit, in which $C = 100\,\text{nF}$, and $R = 10\,\text{k}\Omega$, $R_2 = R_1$ and $L_+ = -L_-$.

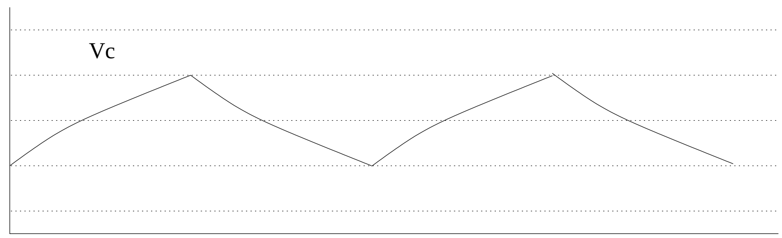
(a) Sketch the output voltage and the voltage across the capacitor as a function of time for at least two periods.

(b) Determine the period of oscillation.



(a) Output voltage and capacitor voltage





(b) The relaxation time constant is RC. We can see that it drops by 2/3 toward it's goal, so the half period is found from

$$\exp\left(-\frac{T/2}{RC}\right) = 1 - 2/3 = 1/3$$

$$T = -2RC \ln\frac{1}{3} = 2RC \ln 3 = 2 \times 10 \times 10^3 \times 100 \times 10^{-9} \times \ln 3 = 2.2\,\text{ms}$$