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.

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)

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.
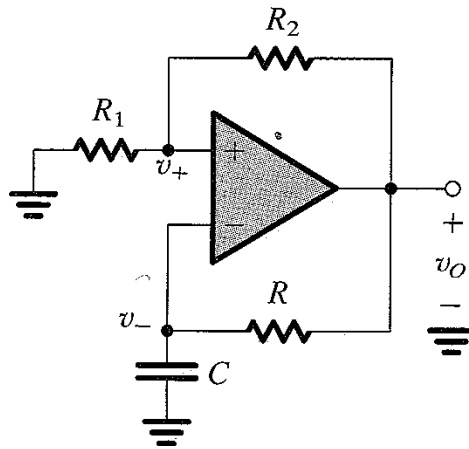
4. Linear regulator

   (a) Use a 723 to make a 5 V regulated supply from a 10 V unregulated input.

   (b) Add current limiting of 100 mA.

   (c) Modify to include foldback current limiting to 30 mA when the output is shorted.

   (d) Add a overvoltage crowbar which activates at 6.2 V. Use an SCR and a Zener diode.

(e) Modify the circuit to use an external power transistor while raising the current limit to 1 A and foldback current to 300 mA.

5. Switching regulator

   (a) Draw a step-up switching regulator.

   (b) Draw the voltage at the inductor/diode node, and the inductor current, when input is 5 V, the output is 15 V, and the regulator is operating in continuous mode.

   (c) Same, but for discontinuous mode operation.

   (d) Draw a step-down switching regulator

   (e) Draw the voltage at the inductor/diode node when the input voltage is 15 V and the output is 5 V, for discontinuous operation.

   (f) Specify a design that will allow the step-down to operate in continuous mode to a current of 10 mA.

6. Sinusoidal oscillator

   (a) Draw the oscillator circuit without the output limiting circuitry.

   (b) Specify the component values which will set the oscillation frequency to 15 kHz

   (c) Specify any remaining component values such that oscillation will be sustained.

   (d) Design a approximately ±12 V limiting circuit for this oscillator using 5.6 V Zener diodes. Don't forget a small resistor. Where does it go, and why?