6.061 / 6.690 Introduction to Electric Power Systems
Spring 2007

Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

6.061/6.690 Introduction to Power Systems

Problem Set 2

Issued: Ses #3

Due: Ses #5

Problem 1: With reference to the simple R-L circuit shown in Figure 1: $R = 100\Omega$ and $L = 100mH$. The switch has been open for a long time before the action begins at time $t = 0$.

1. If the switch is *closed* at time $t = 0$,what is the output voltage v_o as a function of time?
2. Now change the source to be $v_s = 1000cos\omega t$ with $\omega = 2\pi \times 60Hz$. Calculate the output voltage as a function of time.
3. **For 6.690** Simulate the transients described here using MATLAB and its ODE solver ODE23.

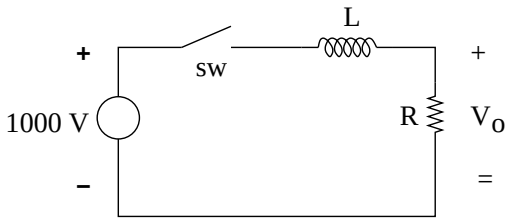

Figure 1: R L Circuit

Problem 2: A 'buck converter' is shown in Figure 2

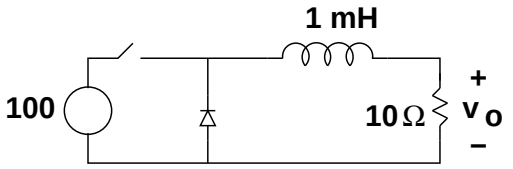

Figure 2: Buck Converter

In this circuit, the switch is closed at a rate of 100,000 times per second and opened again after an interval before the next closing. The ratio of closed time to switching interval is known as the 'duty cycle'.

1. Calculate the average value of the output voltage as a function of the duty cycle.
2. Estimate the peak-peak ripple voltage for a duty cycle of 50%.
3. For 6.690:
   (a) Expand on this last item to estimate the peak-peak ripple voltage as a function of duty cycle.

(b) Use MATLAB to simulate this thing, assuming a duty cycle of 50% starting from zero current in the inductor. Does this match your estimates?

Problem 3: Figure 3 shows a circuit with one inductor, one capacitor and two resistors. The switch is initially open and has been for some time when it is closed at time $t = 0$.

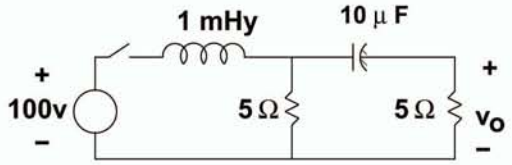

Figure 3: Circuit for problem 3

1. Calculate the output voltage as a function of time.
2. For 6.690: Use MATLAB to simulate the transient.

Problem 4: for 6.690 The circuit of Figure 4 has an input voltage $V = 100v$, an inductor $L = 200mHy$ and a capacitance of $C = 5\mu F$. The system is initially 'at rest' so the output voltage is zero.

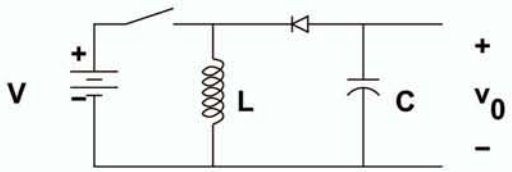

Figure 4: Flyback Circuit

The switch is closed at time $t = 0$ and opened at time $t = 10mS$. Find and sketch:

1. Current through the inductor
2. Current through the capacitance
3. Output Voltage
4. What is the maximum voltage on the capacitor?

Hint: All of the action here stops after a finite time, and you need to consider two different time periods. Focus on when the diode is conducting and when it is not conducting (that is, when can you consider it to be a 'short' and when is it an 'open'?).