18-220 Exam Review

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Bunch of practice problems for 18-220. Problems are sorted by lecture, and can be focused on

- Lab
- Lecture
- Homework problems

Lecture 13

Introduction to RFID circuits.

1. Draw an RFID scanner tag circuit schematic for tha scanner and tag side
2. Why do we need to tune the RFID tags to be at the resonant frequency of the scanning circuit?
3. What is amplitude modulation and how do we use it to transmit data? Why don't we just send the bits directly instead of modulating them?
4. Know that geometry (number of turns, width, height, shape) dictates the inductance of your coil. Also know what would increase/decrease your inductance. You might get a question about "hey this person made an inductor but is getting X response on the plot. What do you suggest they do to make their scanning circuit more accurate?"

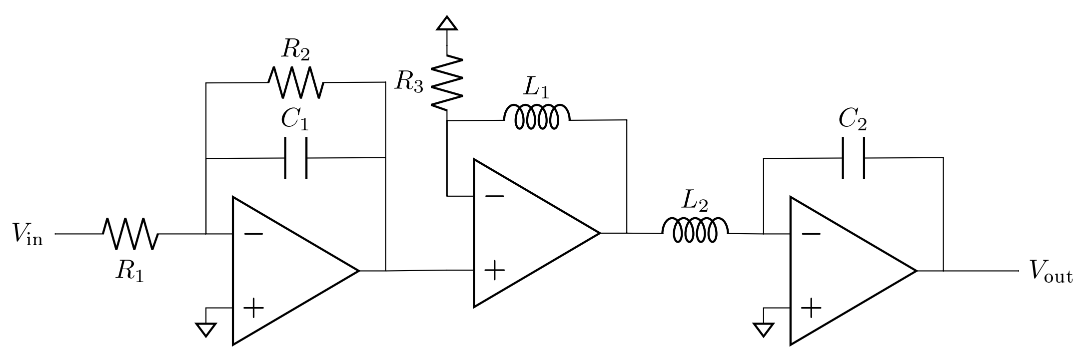
Lecture 14

1. What are the steps to demodulate a signal?
2. What is the 3 dB point? Why is it named that, and what does it indicate about your Bode plot?
3. Make a circuit that is
   (a) Low-pass, using
      i. RC
      ii. RL
   (b) High-pass, using
      i. RC
      ii. RL
   (c) Band-pass, using RLC
4. What is the difference between an active and a passive filter?

Lecture 15

Important lecture as bode plots/transfer functions/feedback are fundamental to this entire unit. Know how to draw bode plots. If you have your Bode plots down, they are free points on an exam.

1. Using an op-amp and R, L, C, make
   (a) A low-pass filter
   (b) A high-pass filter
   (c) A bandpass filter
2. Why do op-amp filters allow us to concatenate filters together?
3. What is a limitation of lower-order filters, and why might we want to use a higher-order filter?
4. Given
$$\frac{10j\omega(1+\frac{j\omega}{100})}{(1+\frac{j\omega}{10})(1+\frac{j\omega}{10^4})(1+\frac{j\omega}{10^4})}, \tag{1}$$
   find the
   (a) Gain at $\omega = 1\,\text{rad/s}$
   (b) Gain at $\omega = 100\,\text{kHz}$
   (c) List all the poles (including multiplicity)
   (d) List all the zeros (including multiplicity)
   (e) Sketch the Bode plots for both magnitude and phase
   (f) What is the phase and gain margin?
5. For the following circuit,



   (a) Find the transfer function.
   (b) Find all poles an zeros.
   (c) What type of filter is this?
   (d) Draw the Bode plot for magnitude and phase
   (e) What is the phase and gain margin?

Lecture 16/17

There's some review on bode plots but the main focus for this one should be op-amp limitations and how feedback comes in for analysis of non-ideal opamps. This is also a meaty topic for exam questions.

1. Describe the assumptions for an ideal opamp.

2. Why would the opamp behavior change with temperature variation?
3. Why do we say an ideal op-amp is like a voltage controlled voltage source (VCVS)?
4. Why do we not want positive gain at 180°?
5. Draw a general feedback diagram with labels, and derive the equation for v_o/v_i
6. Describe the process for finding the following. Draw diagrams too!
   (a) Loop gain
   (b) Open loop gain
   (c) Closed loop gain
   (d) Write the equation that relates LG, OLG, CLG (Black's formula)
7. How can compensation capacitors help with stability?
8. Write the feedback functions for a Butterworth Filter

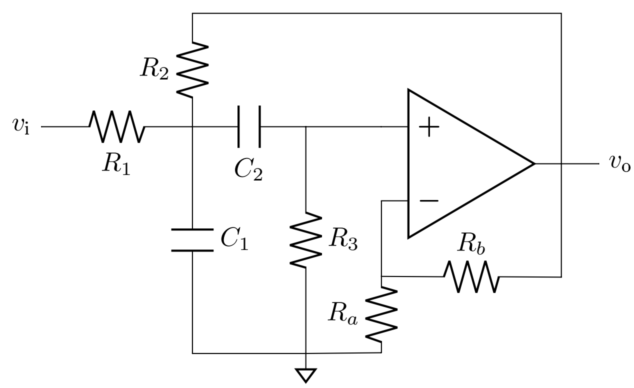


Figure 1: Butterworth Filter

   (a) OLG
   (b) LG
   (c) CLG
   (d) Ideal opamp gain
9. For an ideal opamp, what do we want of the
   (a) Input impedance
   (b) Output impedance

Lecture 18

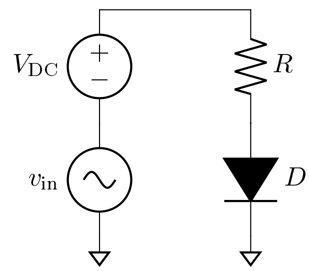
Linearization, why we do it and why it's important.

1. Why do we prefer to have all of our elements to be linear in analysis?
2. Describe the process for finding (this is more of a review question)
   (a) Thevenin equivalent
   (b) Norton Equivalent
   (c) Input impedance
   (d) Output impedance
3. Understand why you might use a Taylor series for a nonlinear element
4. Briefly understand what the Newton method is doing

Lecture 19

Operating circuits at AC around a DC operating point, small signal analysis.

1. Given the following circuit,



Assume the diode can be modified with the standard diode equation, with $V_{\mathrm{T}} = 0.026\,\mathrm{V}, I_{\mathrm{S}} = 1 \times 10^{-12}\,\mathrm{A}$

(a) If $V_{\mathrm{DC}} = 5\,\mathrm{V}$, find the required R to achieve a bias current of $30\,\mathrm{mA}$through the diode.

(b) At this DC operating point, what is the change in current with respect to the change in voltage?

(c) What is the change in current with respect to the change in the ***operating voltage point***?

(d) If we want to increase $V_{\mathrm{DC}} = 12\,\mathrm{V}$ and still maintain $30\,\mathrm{mA}$through the diode, what resistor can we add in parallel to R to get our desired operating point?

(e) We observed two operating points in this problem, $V_{\mathrm{DC}} = 5\,\mathrm{V}, 12\,\mathrm{V}$. Which operating point gives a bigger current swing?

Formulas

- Resonant frequency of LC circuit

$$\omega = \frac{1}{\sqrt{LC}} \tag{2}$$

- Decibel to absolute gain relation

$$\mathrm{Gain(dB)} = 20 \log_{10} \frac{V_{\mathrm{out}}}{V_{\mathrm{in}}} \tag{3}$$

- Canonical transfer function

$$\frac{V_{\mathrm{out}}}{V_{\mathrm{in}}} = \frac{-Aj\omega\omega/\omega_{\mathrm{z}}}{(1 + j\omega/\omega_1)(1 + j\omega/\omega_2)} \tag{4}$$