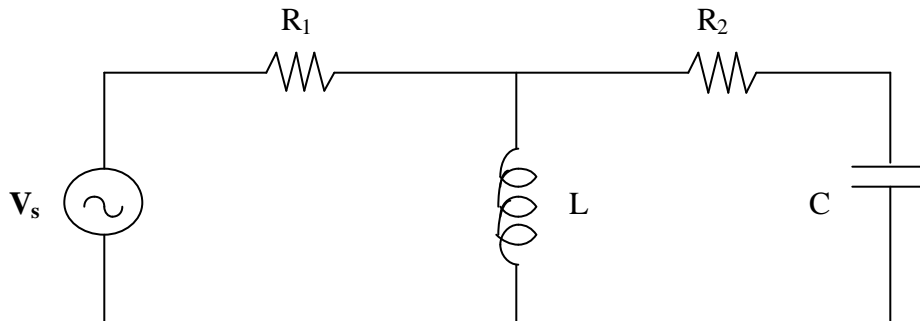


EE 70 Final Exam
Closed Book, Calculators Allowed
Two Pages of Notes Allowed (8.5" x 11", both sides ok)
Tuesday, December 9th (8 am – 11 am)

Please do all of your work on a separate sheet of paper
Final answers should be circled next to your work
To receive full (or partial) credit, you must show your work
Unless otherwise specified, each question is worth two points

For problems 1–3, consider the following circuit:

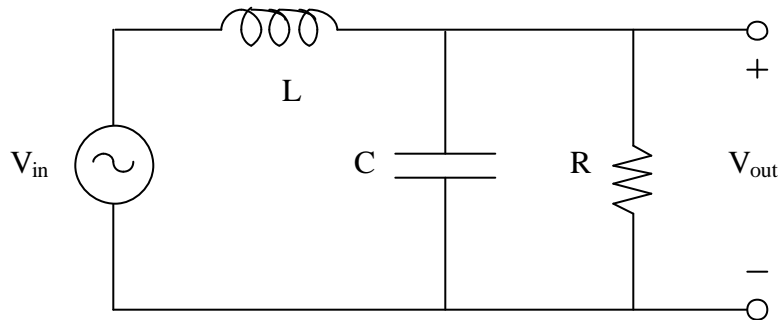


Given $V_s = 2e^{0j}$, $\omega = 2$, $R_1 = 4 \Omega$, $R_2 = 4 \Omega$, $L = 2 \text{ H}$, and $C = 0.25 \text{ F}$. The objective is to use mesh analysis to find the two mesh currents.

1. Using KVL, write two equations in terms of phasor voltages. (Redraw the circuit and clearly define the phasor voltage polarities) Convert the phasor voltages of the passive elements into phasor currents. (make sure to clearly define your phasor currents)
2. Solve for the two mesh currents. Show all steps. (“done on calculator” is not a sufficient answer and will not result in full credit) Answers can be left in phasor form as a single, simplified complex number.
3. Find $V_s(t)$ and the two mesh currents as a function of time.

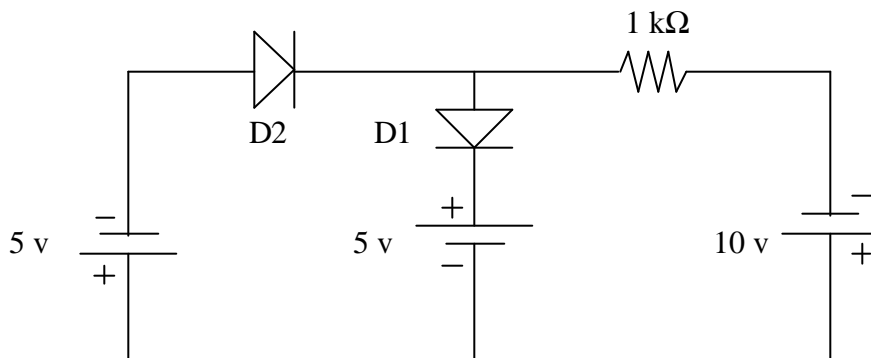
For extra credit (2 pts.): Draw a phasor diagram, showing V_s and the two mesh currents.

For problems 4–7, consider the following circuit:



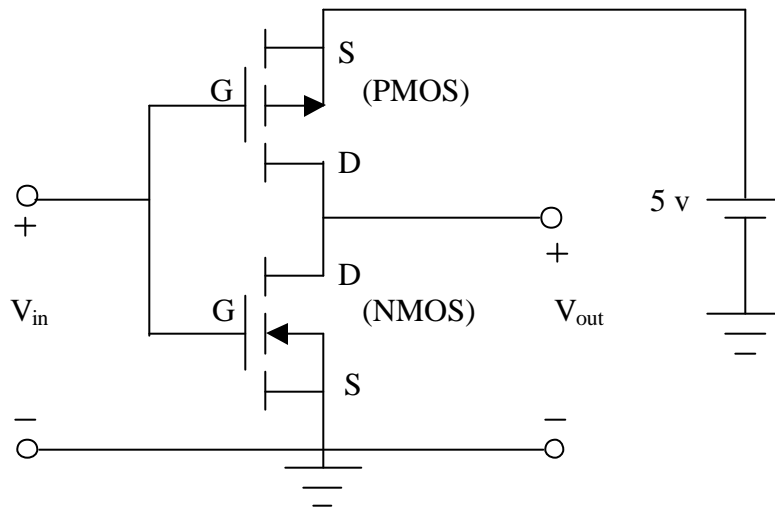
4. Find the transfer function, i.e. $V_{\text{out}}(\omega)/V_{\text{in}}(\omega)$, in terms of R , L , and ω (or f).
5. What is the magnitude of the transfer function, i.e. $|H(\omega)|$?
6. What is $|H(\omega)|$ equal to for very low frequencies? For very high frequencies? What happens at resonance? (i.e. $\omega = \omega_0 = \frac{1}{\sqrt{LC}}$) What kind of a filter do we have here?
7. Sketch the magnitude Bode plot for this filter. Label all critical points and slopes. Use $R = 2 \Omega$, $L = \frac{1}{4} \text{ H}$, and $C = \frac{1}{8} \text{ F}$. Show how you obtained the value for any non-zero slopes.

For problems 8–9, consider the following circuit:



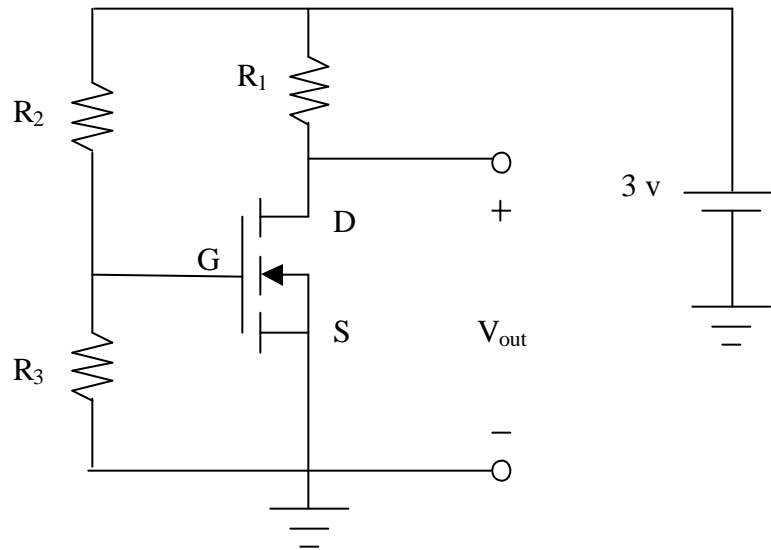
- 8–9. There are a total of 4 different possible states for the two diodes. Assuming a large-signal diode model, analyze the circuit for each of the 4 possibilities. Assume the diodes are made from germanium and thus require a 0.3 v bias in order to conduct. For each case, find the voltage and current through each diode and explain why or why not the original assumptions are valid.

For problems 10–14, use the following circuit (which is an CMOS inverter):



10. Sketch the I_{ds} – V_{ds} characteristics of each MOS device. Assume that $K = 2 \text{ mA/V}^2$ for both the NMOS and PMOS device and $V_{to, \text{NMOS}} = 1$ and $V_{to, \text{PMOS}} = -1$. Show the curves for $V_{gs, \text{NMOS}} = 0, 1, 2,$ and 3 v and $V_{gs, \text{PMOS}} = 0, -1, -2,$ and -3 v
- 11a. What is V_{in} equal to in terms of the NMOS and PMOS voltages?
- 11b. What is V_{out} equal to in terms of the NMOS and PMOS voltages?
12. Suppose that $V_{in} = 5 \text{ v}$. What region is each transistor operating in? Use these results to find V_{out} .
14. Now suppose that $V_{in} = 3 \text{ v}$. Using one of the curves from each of the graphs in #10, overlay the two curves to get an estimate of V_{out} . (Use your result from #13 to shift the PMOS graph)

For problems 15–18, use the following circuit:



For the NMOS transistor, assume $K = 2 \text{ mA/V}^2$ and $V_{to} = 0.5$

15. If $R_2 = 3 \text{ M}\Omega$ and $R_3 = 300 \text{ k}\Omega$, V_{out} is independent of R_1 . What is V_{out} ?
16. Change the circuit by choosing a new value of R_3 such that $V_{GS} = 1.5 \text{ v}$.
17. Using the new value for R_3 , if the transistor is operated in the triode region, what range of values for V_{out} can be obtained?
18. Choose a value of R_1 such that $V_{out} = 0.5 \text{ v}$.

For extra credit, choose a value of R_1 such that $V_{out} = 2 \text{ v}$.

END OF FINAL EXAM

(total points available: $17 \times 2 = 34$...#13 is not counted since it is a repeat of #11b)