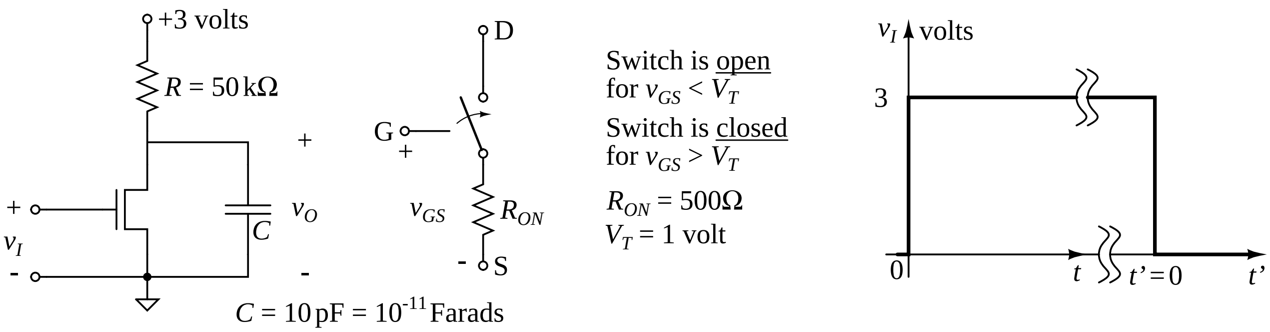
Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.002 – Circuits and Electronics
Spring 2003

Handout S03-032 - Homework #6

Issued: Wed. Mar 12
Due: Fri. Mar 21

Problem 6.1: The FET in the circuit below can be modeled with the switch-resistor (SR) model shown.



For $t < 0$ the input voltage v_I is zero. At $t = 0$ v_I changes instantly to $v_I = 3$V. A long time later at a time $t' = 0$, the input voltage changes instantly to zero, as shown in the sketch above.

(A) What is v_O for $t < 0$?

(B) Draw a circuit diagram which incorporates the SR model and applies for $t > 0$ (in the interval of time for $t' < 0$).

(C) Write a differential equation which describes $v_O(t)$.

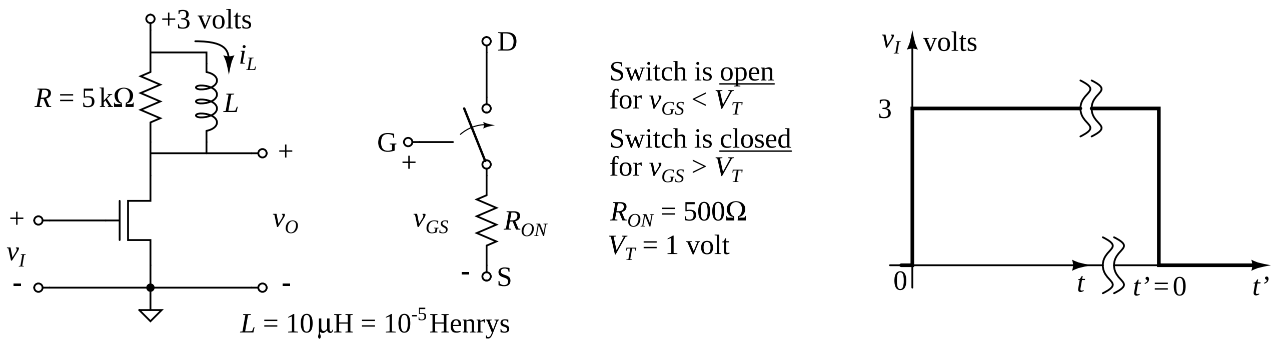
Hint: Think node equation.

(D) Solve this equation for $t > 0$. Sketch and dimension your result and label initial and final (asymptotic) values of $v_O(t)$ and mark the numerical value of the time constant on the time axis.

(E) Repeat Parts (B) (C) and (D) for the second interval of time starting at $t' = 0$. Note that the differential equation changes.

(F) Explain why the two time constants differ by more than an order of magnitude.

Problem 6.2: The FET in this circuit is the same as that in problem 6.1 and can be describe by the same SR model. The waveform for v_I is the same as in Problem 6.1.



(A) What are the values of $v_O(t)$ and $i_L(t)$ for $t < 0$?

(B) Write a differential equation for $i_L(t)$ which applies in the first interval of time where $t > 0$.

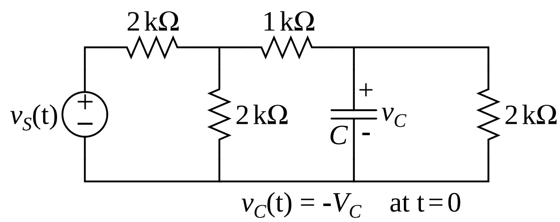
Hint: To avoid getting tangled up in this write a node equation at the drain terminal of the FET in terms of v_O and i_L. Then use the defining constituent relation for the inductor to replace v_O.

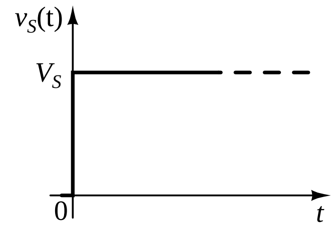
(C) Solve this equation for $i_L(t)$ for $t > 0$. From this result derive an expression for $v_O(t)$. Sketch and dimension both curves, labeling initial and final values and the numerical value of the time constant.

(D) Repeat parts (A), (B), and (C) for the second interval of time starting at $t' = 0$. Note that the differential equation changes.

(E) Explain why the value of v_O at $t' = 0+$ is so large.

Problem 6.3: In the circuit below $v_I(t)$ is a step of magnitude V_S at $t = 0$. That is, $v_S(t) = V_S u_{-1}(t)$. At $t = 0$ the voltage $v_C(t)$ across the capacitor is $-V_C$ volts as a result of some previous excitation.





(A) Write a differential equation for $v_C(t)$ for $t > 0$.

Hint: Recall problem 4.2 and make use of a Thevenin or Norton equivalent before forming the differential equation.

(B) Let $C = 1\mu\text{F} = 10^{-6}\text{F}$ and determine the value of the time constant which governs the transient response of this circuit.

(C) Solve the differential equation from Part A) for $v_C(t)$ for $t > 0$. Sketch and dimension your result and label initial and final values.

(D) There is a value of $v_C(0)$ for which there is no transient. What is it?