Department of Electrical Engineering and Computer Sciences
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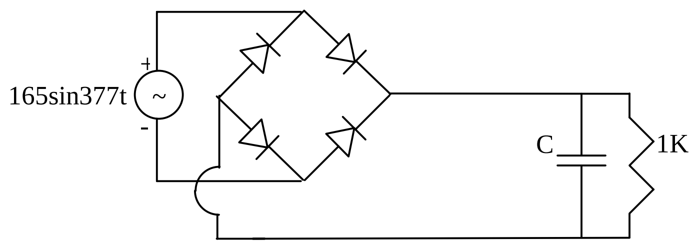
EECS 40 **Summer 2002**

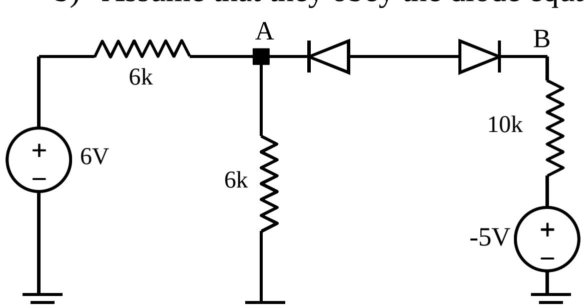
Problem Set 8
Due Fri Jul 26 at 12pm

1) Text 13.3. You are to do part 1 by solving the equation. Either use trial and error or use the solve button on your calculator or spreadsheet.
2) Consider the simple half wave rectifier circuit discussed in Example 13.6 of the text. We are interested in having very small "ripple" in the output voltage, and want to choose an appropriate capacitor. Note that if the ripple is small (that is the "droop" of the voltage between charging cycles is small), then (t_1-t_C) is almost the full period, 1/60 second. With this approximation, estimate C required to guarantee 0.5V of droop. (The minimum value for C to guarantee the voltage does not drop more than 0.5V between charging cycles.)
3) Now lets use a "full wave rectifier" instead. The circuit which replaces the single diode in Fig 13.14 (a) is shown below. For the same 1K resistor load as in Problem 2, find the minimum capacitor to guarantee less than 0.5V ripple. Hint: make a similar approximation as you did in Prob. 2 regarding the time between charging cycles.



4) Find V_A and V_B for the circuit below

a) Assume that the diodes are perfect rectifiers.
b) Assume that they obey the diode equation with Is = 10^{-16} A.



5) NMOS + Resistor Load as Inverter

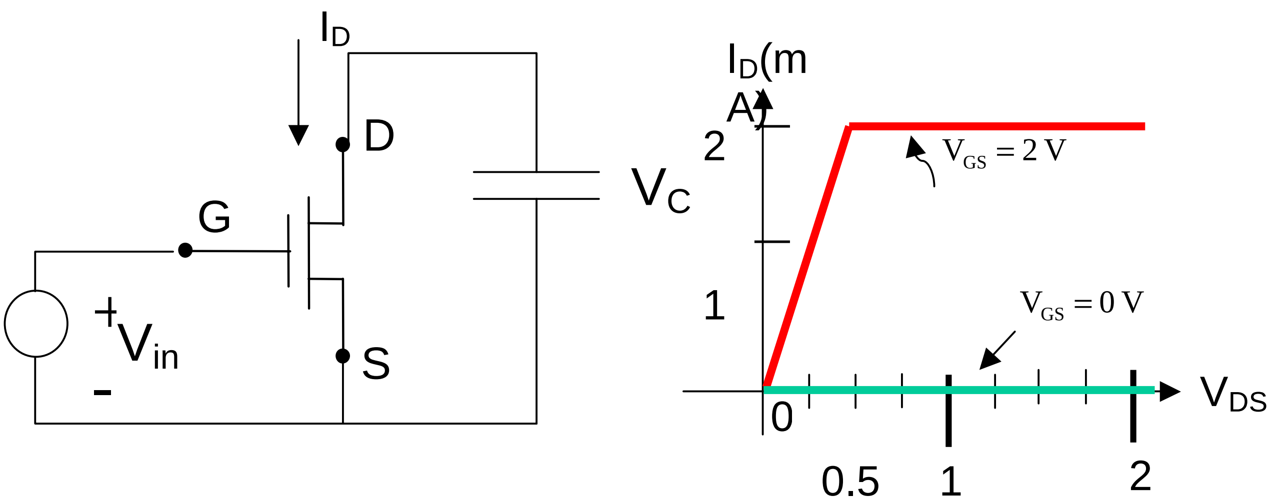
A really dumb way to make an inverter is to combine an NMOS transistor and a resistor. See Figure 15.11. But this circuit has conceptual value (and some very brief historical relevance, if we regard the MOS as a "generic active device". Consider the specific circuit of 15.11 but with a 1pF capacitance at the output node. Suppose the input has been at 7 V for a very long time (with output = 0.6V as can be read off the intersection of the load line and the V_{GS} =7V curve) and the input suddenly jumps to 0V. Calculate and plot the behavior of V_{OUT} versus time.

a) How long does it take the output to go from 0.6V to a value of 3.8 V?

b) What is the power dissipation when the input is 7V ? (μW per inverter).

6) Charging Capacitors with voltage sources and current sources.

Consider the simple circuit below. The device I-V characteristic is given in the figure.



Initially V_{in} =V_{GS} is low and the transistor is an open switch. We assume the capacitor is initially charged to V_{DD} = 2V. At t=0 the input voltage switches to 2V and the transistor becomes more like a closed switch. But at t=0+ , the voltage V_C must remain at 2V, because a capacitor voltage cannot jump. Note that the transistor current is a constant 2mA as long as V_D >0.5V. We want to calculate the timing.

a) Can you solve for the form of V_C(t) during the time that the voltage drops from 2V to 1V? Hint: the I-V characteristic suggests that the current discharging the capacitor is a constant..

b) How long does it take the capacitor voltage to reach 1V?

(c) Now lets compare this with the result obtained with a "switch model" for the MOS transistor. To do this you just replace the MOS transistor in the circuit with a switch in series with a resistor R. Assume the switch is closed if V_G is 2V and it is open if V_G = 0V. Assuming the same initial conditions as before (V_C = 2V) how long does it take for the output to drop to 1V if V_G goes high (the answer is in terms of R, of course)?

(d) How big must R be in order for the time computed in (c) to be the same as in (b)?

(e) Plot the I-V characteristic of this resistor on the same axes as the transistor (that means copy the I-V graph above and then plot the resistor on the same graph.

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