Massachusetts Institute of Technology
Electrical Engineering and Computer Science Department

6.002 Electronic Circuits

Homework #6
Handout F00-031

Issued: Oct. 12, 2000 - Due: Oct. 20, 2000

Read Sections 8.1 - 8.2

Exercise 6-1: Exercise 8.1 from Chapter 8

Exercise 6-2: Exercise 8.2 from Chapter 8

Problem 6-1: (Exercise 8.5 from Chapter 8 with part e omitted)

Consider again the MOSFET amplifier shown in Figure 9.44 (See Notes). Assume as before that the amplifier is operated under the saturation discipline.

a) What is the range of valid input voltages for the amplifier? What is the corresponding range of valid output voltages?

b) Assuming we desire to use voltages of the form Asin(wt) as AC inputs to the amplifier, determine the input bias point V_I for the amplifier which will allow for the maximum input swing under the saturation discipline. What is the corresponding output bias point voltage V_O?

c) What is the largest value of A that will allow the saturation region operation for the bias point determined in (b)?

d) What is the small signal gain of the amplifier for the bias point determined in (b)?

Problem 6-2: (Problem 8.1 from Chapter 8 with part c omitted)

This problem studies the small-signal analysis of the MOSFET amplifier discussed in Problem 7.3 (Figure 7.75) in the previous chapter.

a) First consider the biasing the amplifier. Determine V_{IN}, the bias component of v_{IN}, so that v_{OUT} is biased to V_{OUT} where $0 < V_{OUT} < V_S$. Find V_{MID}, the bias component of v_{MID} in the process.

b) Next, let $v_{IN} = V_{IN} + v_{in}$ where v_{in} is considered to be a small perturbation of v_{IN} around V_{IN}. Make the substitution for v_{IN} and linearize the resulting expression for v_{OUT}. Your answer should take the form $v_{OUT} = V_{OUT} + v_{out}$, where v_{out} takes the form $v_{out} = Av_{in}$. Note that v_{out} is the small-signal output and A is the small-signal gain. Derive an expression for A.

Problem 6-3: (Problem 8.2 from Chapter 8 with parts e and f omitted)

Consider again the buffer described in Problem 7.5 (Figure 7.76) in the previous chapter. Perform a small-signal analysis of this circuit according to the following steps. Assume that the MOSFET operates in its saturation region and continue to use the SCS MOSFET model.

a) Draw the small-signal circuit model of the buffer.

b) Show that the small-signal transconductance g_m of the MOSFET is given by

$$g_m = K(V_{IN} - V_{OUT} - V_T)$$

where V_{IN} and V_{OUT} are the bias, or operating-point, input and output voltages, respectively.

c) Determine the small-signal gain of the buffer. That is, determine the ratio v_{out}/v_{in}.

d) Determine the small-signal output resistance of the buffer. That is determine the equivalent resistance of the buffer at the output port of its small-signal model with $v_{in} = 0$. (Hint: This is the Thevenin equivalent resistance of the small-signal circuit looking into the output port.)

e) Determine the small-signal input resistance of the buffer. That is determine the equivalent resistance of the buffer at the input port of its small-signal model. (Hint: This is the Thevenin equivalent resistance of the small-signal circuit looking into the input port.)