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303H Fall 2009 – Homework 5 Due Th 10/15/09

1. [60 points] [gain of a source follower]

   For the source follower of the small ~~frequency~~ signal equivalent circuit of Figure 6.51 (a), p. 638 of Sedra/Smith, [with symbolic but real parameters]

   a) Draw the full circuit diagram with the transistor symbol and biasing including an input coupling capacitor (note especially the bulk connection).
   b) Using node equations find the 1x2 transfer function matrix, T(s), for the given equivalent circuit of the above mentioned figure. Here

$$[\mathrm{Vo}] = \mathrm{T(s)}\begin{bmatrix}\mathrm{Vsig}\\ \mathrm{Vbs}\end{bmatrix}$$

   c) Explain why the entries of the transfer function matrix are at most degree 2 in the complex frequency, s, even though there are three capacitors present {which normally means degree 3}.
   d) That being the case, the numerators and denominators can be factored exactly. Give the zeros and poles and indicate their relative positions in the complex s-plane.
   e) Sketch the {magnitude of the} frequency response of Vo/Vsig(jω) assuming Vbs=0; repeat for Vo/Vbs(jω) assuming Vsig=0 and compare.

2. [40 points] [cascade of inverters]

   Use the 4007s to make CMOS inverters which are biased at VDD=10V and VSS=0.

   a) Connect the inverters in cascade as shown in Figure 11.1 (b), page 1014 of Sedra/Smith, and run Spice to obtain the curves of Figure 11.1 (c) [this is a DC run]. Plot v_X and v_Z versus v_W as well as the straight line shown in that figure. Record the location of the points A, B and C and comment upon them with respect to VDD {especially note B in relation to VDD/2}.
   b) Connect the inverters as shown in Figure 11.1 (a) and obtain Spice runs of the three voltages (now in time via transient response). Submit those as well as v_X and v_Z versus v_W. You will probably need to move off of an equilibrium point, which can be done by shocking the W lead with a short current source pulse.
   c) Insert a capacitor, Cw, of 10nFd from W to ground and repeat part b) above for various initial conditions on Cw, especially ones for the points A, B, C.