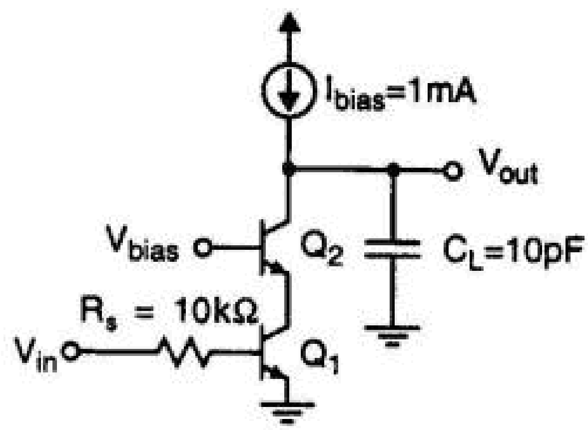
*Dept. of Electrical and Computer Engineering*

CE354 — Spring, 1999

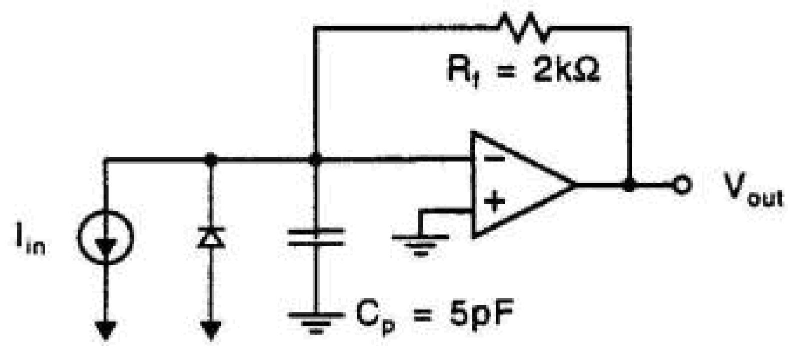
**Final Exam**

- npn bipolar transistors: $\beta = 100$, $V_A = 80$ V, $I_S = 1\times10^{-15}$, $\tau_b = 13$ ps, $\tau_s = 4$ ns, $r_b = 330\ \Omega$
- N-channel MOS transistors: $\mu_n C_{ox} = 190\ \mu A/V^2$, $V_{tn} = 0.6$ V, $\gamma = 0.5\ V^{1/2}$, $r_{ds}(\Omega) = 9000L(\mu m)/I_D(mA)$ in active region, $C_j = 1.1\times10^{-3}\ pF/(\mu m)^2$, $C_{jsw} = 2.0\times10^{-4}\ pF/\mu m$, $C_{ox} = 4.5\times10^{-3}\ pF/(\mu m)^2$, and $C_{gs(overlap)} = C_{gd(overlap)} = 3.0\times10^{-4}\ pF/\mu m$
- P-channel MOS transistors: $\mu_p C_{ox} = 70\ \mu A/V^2$, $V_{tp} = -0.7$ V, $\gamma = 0.6\ V^{1/2}$, $r_{ds}(\Omega) = 7000L(\mu m)/I_D(mA)$ in active region, $C_j = 1.3\times10^{-3}\ pF/(\mu m)^2$, $C_{jsw} = 2.5\times10^{-4}\ pF/\mu m$, $C_{ox} = 4.5\times10^{-3}\ pF/(\mu m)^2$, and $C_{gs(overlap)} = C_{gd(overlap)} = 3.0\times10^{-4}\ pF/\mu m$




1. Find the mid-band gain of the amplifier shown. Assume the d.c. bias voltages are such that all transistors are in the active region. Also assume the current source is ideal. Use BJT model parameters from the cover page.

2 For the same amplifier shown in Fig. 1, and assuming $C_\pi = 500fF$, $C_\mu = 20fF$, and $C_{CS} = 75fF$, estimate the frequencies of the first and second pole of the transfer function of the gain (i.e. the two lowest-frequency poles).




: The fiber-optic preamp shown has an optical detector with 5pF parasitic capacitance, a 2kΩ feedback amplifier, and an amplifier gain of 100. Assuming the parasitic capacitance of the detector dominates the frequency response, estimate the -3dB frequency of the gain using feedback techniques. Assume the input resistance of the open-loop op-amp is infinite and the input capacitance is zero.

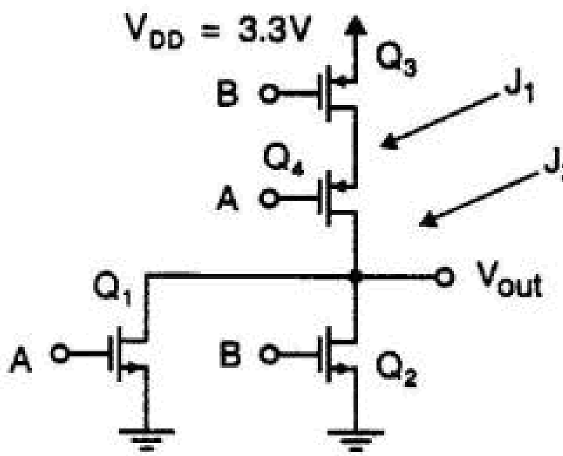
An op-amp has a transfer function function at mid-band and larger frequencies that is approximately given by

$$A(s) \cong \frac{\omega_{ta}}{s} \frac{1}{1+\frac{s}{\omega_{p2}}} \qquad (1)$$

Assume the op-amp is used in a feedback loop having a feedback constant $\beta$ that is frequency independent. (a) Derive equations for the resonant frequency and Q-factor of the denominator of the closed-loop configuration. Note: the denominator can be expressed as:

$$D(s) = s^2 + s\frac{\omega_o}{Q} + \omega_o^2 \qquad (2)$$

(b) Assuming the phase margin is $75°$, find $\omega_t$ where $\omega_t$ is the unity-gain frequency of the loop gain. Assume $\beta = 0.2$, $\omega_{p2} = 2\pi \times 10^8 \text{ rad/s}$, and $\omega_{ta} = 5\pi \times 10^8 \text{ rad/s}$.




Assume all p-channel trasistors have $W/L = 5\mu m/0.5\mu m$ and all n-channel transistors have $W/L = 1.25\mu m/0.5\mu m$. (a) Estimate the total junction capacitance at the output node ($J_2$) due to depletion capacitances only. Ignore any load capacitance. State explicitly any assumptions used. (b) Assuming the total capacitances at junctions $J_1$ and J2 are $C_{p1} = 10fF$ and $C_{p2} = 30fF$, respectively (Note: these are not the correct answers to part (a)), estimate the output $t_{+70\%}$ rise time assuming $A = '0'$ and $B$ changes from a '1' to a '0' at t=0. Any required parameters should be taken from the cover page.