Exercises for Tutorial 4: Frequency Response and Stability

1) Problem 10.1 in the course book.

$A_0 = 31.3$ dB (Using linear approximation $= 29.9$ dB)

2) Problem 10.9 in the course book. In part (b) assume that the gain crossover point is the same as that of part (a). Also assume $\mu_n C_{ox} = 134\ \mu A/V^2$, $\lambda_n = 0.1\ V^{-1}$ and $\lambda_p = 0.2\ V^{-1}$. All transistors are in saturation region.

a) PM $= 60.8°$ (Using linear approximation $= 56.3°$)

b) $C_{Ymax} = 516$ fF (Using linear approximation $= 434$ fF)

3) Figure 8 shows an amplifier schematic. For simplicity we can ignore all parasitics of M_1 and M_2. Also, we assume $g_{m1} \gg 1/r_{o1}$ and $\gamma = 0$.

a) Determine the transfer function of the amplifier.

$$H(s) = \frac{g_{m1}}{g_{m1} + sC_1} \frac{-g_{m2}(R \parallel r_{o2})}{1 + s(R \parallel r_{o2})C_2}$$

b) If $g_{m1} = g_{m2} = 1\ mA/V$, $R = r_{o2} = 20\ k\Omega$ and $C_1 = C_2 = 1\ pF$, calculate the phase margin of the circuit.

PM $= 59.3°$

c) Use the assumptions in part (b) to calculate the AC gain, if the input frequency is $f = \frac{1}{2\pi} \times 10^8\ Hz$.

$A_{ac} = 7$

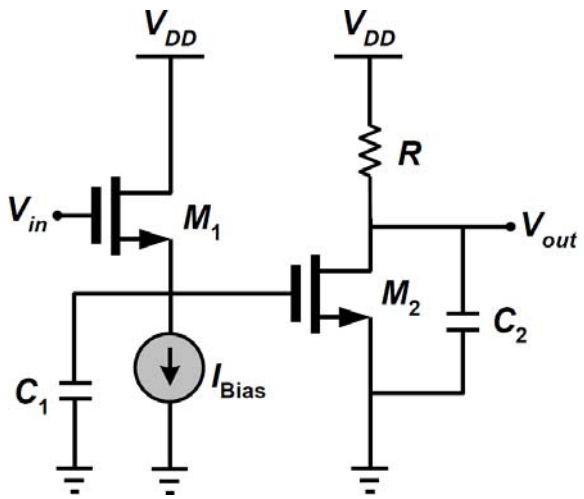

Figure 8 An amplifier schematic.

4) Figure 9 shows an amplifier schematic. For simplicity we can ignore all parasitics of M_1 and M_2. Also we assume $\lambda = 0$.

   a) Determine the transfer function of the amplifier.

$$H(s) = -\frac{g_{m1}(1 + sRC_1)}{s^2RC_1C_2 + s(C_1 + C_2) + g_{m2}}$$

   b) If the amplifier behaves like a single-pole system, show $g_{m2}R = 1$.

   c) If $g_{m1} = g_{m2} = 0.32\ mA/V$, $R = 5\ k\Omega$, $C_1 = 0.2\ pF$ and $C_2 = 1\ pF$, calculate the phase shift yhrough the amplifier circuit for an input signal with $f = 143.3\ MHz$.

$$\text{Phase shift} = 72.4°$$

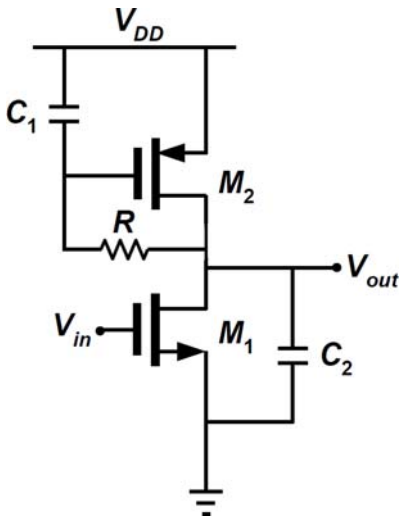

Figure 9 An amplifier schematic.

5) An amplifier circuit has two poles at $100\ Mrad/s$ and $500\ Mrad/s$, with no zeros. Calculate the DC gain of the amplifier to get a phase margin of $90°$.

$$A_0 = 2.7$$

6) Figure 10 shows a source-follower circuit. For simplicity we can ignore all parasitics. Also we assume $\lambda = 0$.

a) Determine the transfer function of the circuit.

$$H(s) = \frac{g_{m1} + sC_1(1 + g_{m1}R)}{s^2RC_1C_2 + s(g_{m1}RC_1 + C_1 + C_2) + g_{m1}}$$

b) If $g_{m1} = 1\ mA/V$, $R = 10\ k\Omega$, $C_1 = 1\ pF$ and $C_2 = 0.1\ pF$, calculate the AC gain and the phase shift through the source-follower circuit for an input frequency of $5\ Grad/s$.

$$A_{ac} = 0.9$$
$$\text{Phase shift} = 22.3°$$

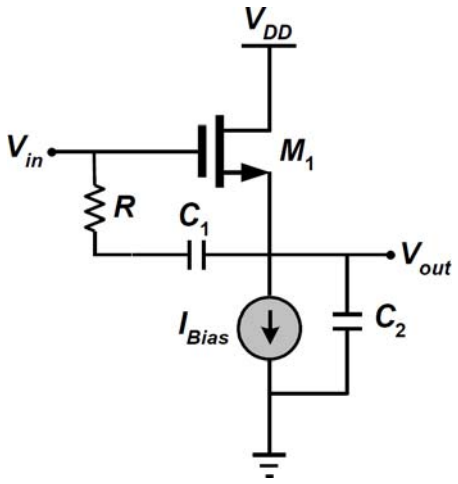

Figure 10 Source follower.