EE/CE 3311 Electronic Circuits

Summer 2014

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Homework #7

Due: Beginning of class Thursday July 24

1. Textbook problem #3.4. Ignore the $V_i$ and $V_o$ questions. Answer only: “What is the maximum voltage gain of this stage?”
2. Textbook problem #3.9a and #3.9d
3. Textbook problem #3.14
4. Textbook problem #3.22
5. Textbook problem #4.3 (ignore requirement c)
3.4 For the common-source amplifier of Fig. 3.12, calculate the small-signal voltage gain and the bias values of $V_i$ and $V_o$ at the edge of the triode region. Also calculate the bias values of $V_i$ and $V_o$ where the small-signal voltage gain is unity with the transistor operating in the active region. What is the maximum voltage gain of this stage? Assume $V_{DD} = 3\text{V}$, $R_D = 5\text{k}\Omega$, $\mu_n C_{ox} = 200 \mu\text{A/V}^2$, $W = 10 \mu\text{m}$, $L = 1 \mu\text{m}$, $V_f = 0.6 \text{V}$, and $\lambda = 0$. Check your answer with SPICE.

Figure 3.12 (a) Resistively loaded, common-source amplifier. (b) Small-signal equivalent circuit for the common-source amplifier.
3.9 For the common-drain amplifier of Fig. 3.73, assume \( W/L = 10 \) and \( \lambda = 0 \). Use Table 2.2 for other parameters. Find the dc output voltage \( V_O \) and the small-signal gain \( v_o/v_i \) under the following conditions:

(a) Igaoring the body effect and with \( R \to \infty \).
(b) Including the body effect and with \( R \to \infty \).
(c) Including the body effect and with \( R = 100k\Omega \).
(d) Including the body effect and with \( R = 10k\Omega \).

![Figure 3.73 Circuit for Problem 3.9.](image-url)
3.14 Determine the input resistance, transconductance, output resistance, and maximum open-circuit voltage gain for the CS-CG circuit of Fig. 3.38 if $I_{D1} = I_{D2} = 250$ μA. Assume $W/L = 100$, $\lambda = 0.1V^{-1}$, and $\chi = 0.1$. Use Table 2.2 for other parameters.

![Cascode amplifier using MOSFETs](image)

**Figure 3.38** Cascode amplifier using MOSFETs.
3.22 Consider the circuit of Fig. 3.80 except replace both \( npn \) transistors with \( n \)-channel MOS transistors. Neglect the body effect, and assume \( \lambda = 0 \). Use half-circuit concepts to determine the differential-mode and common-mode gain of this modified circuit.

![Circuit Diagram](image)

**Figure 3.80** Circuit for Problem 3.21.
4.3 Design a simple MOS current mirror of the type shown in Fig. 4.4 to meet the following constraints:

(a) Transistor $M_2$ must operate in the active region for values of $V_{OUT}$ to within 0.2 V of ground.
(b) The output current must be 50 µA.
(c) The output current must change less than 1 percent for a change in output voltage of 1 V.

Make $M_1$ and $M_2$ identical. You are to minimize the total device area within the given constraints. Here the device area will be taken to be the total gate area ($W \times L$ product). Assume $X_d = 0$ and take other device data from Table 2.4.

![Diagram](image)

**Figure 4.4** A simple MOS current mirror.