

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Electrical Engineering and Computer Science

6.301 Solid State Circuits

Spring Term 2003
 Problem Set 1

Issued : February 4, 2003
 Due : Friday, February 7, 2003

The prerequisites for 6.301 are circuits, device physics, and linear systems. Officially, this requirement is 6.012, which implies that you have also taken 6.003. However, previous experience with transistors (such as in 6.101) can sometimes substitute for a complete device physics course. Some previous laboratory experience with circuit construction is assumed, such as in 6.002 or 6.101. This problem set should remind you of what you already know. You should feel comfortable with the following problems if you intend to take 6.301.

Problem 1: For the following transfer functions, find the 3 dB bandwidth (the frequency at which the magnitude of the frequency response is 0.707 of the DC gain) in hertz.

$$A_1(s) = \frac{1}{\tau s + 1} \quad A_2(s) = \frac{10}{(\tau s + 1)^2}$$

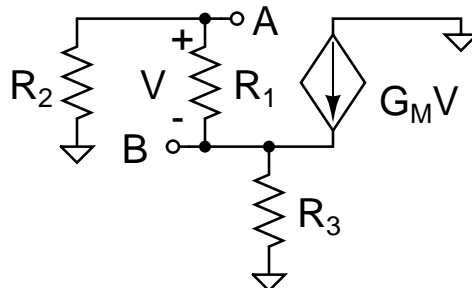
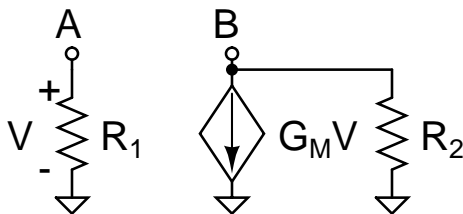
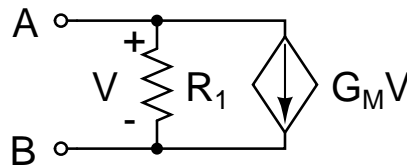
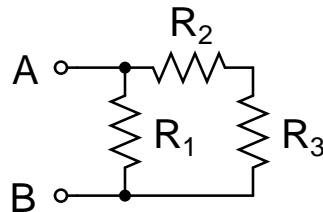
$$A_3(s) = \frac{100}{(\tau s + 1)^M} \quad A_4(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

Problem 2: For the following transfer functions, sketch the pole-zero plot, the Bode plot (magnitude and phase), and the step response.

$$H_1(s) = \frac{1}{s^2} \quad H_2(s) = \frac{2}{s + 1} \quad H_3(s) = \frac{10}{s^2 + 2s + 1} \quad H_4(s) = \frac{10}{s^2 + s + 1}$$

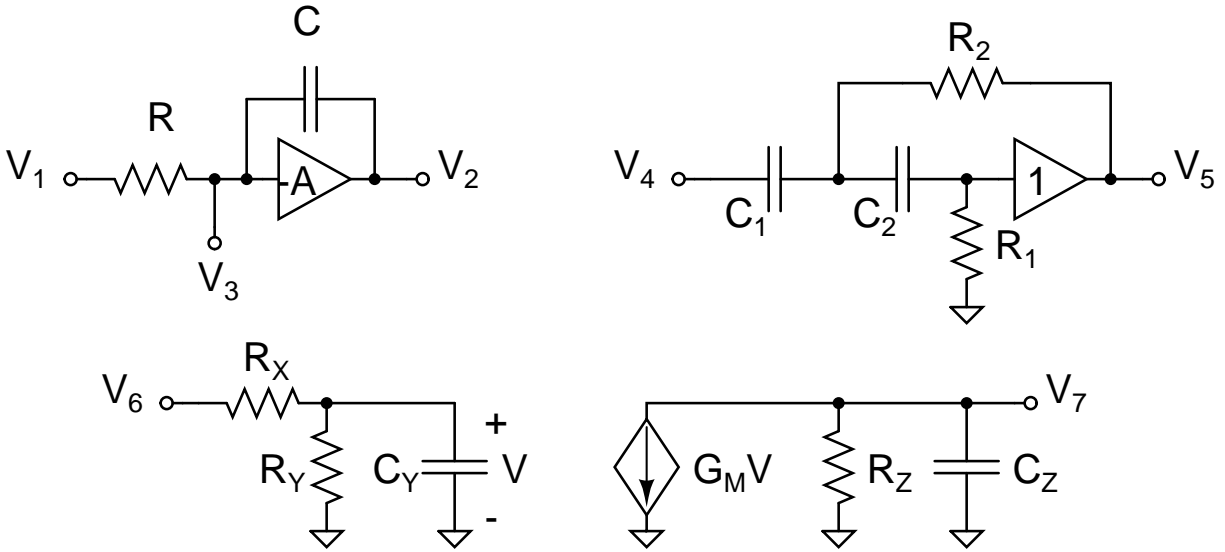
$$H_5(s) = \frac{s + 2}{s + 1} \quad H_6(s) = \frac{s + 1}{s + 2} \quad H_7(s) = \frac{s + 1}{s^2 + s + 1} \quad H_8(s) = \frac{s - 1}{s + 1}$$

Problem 3: Find the Thevenin resistance from node A to node B in the following circuits.

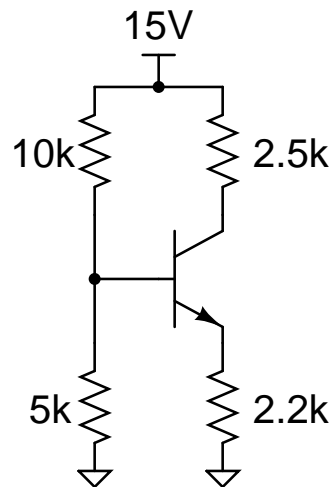


Problem 4: For the following circuits, find the transfer functions

$$\frac{V_2}{V_1}(s) \quad \frac{V_3}{V_1}(s) \quad \frac{V_5}{V_4}(s) \quad \text{and} \quad \frac{V_7}{V_6}(s)$$

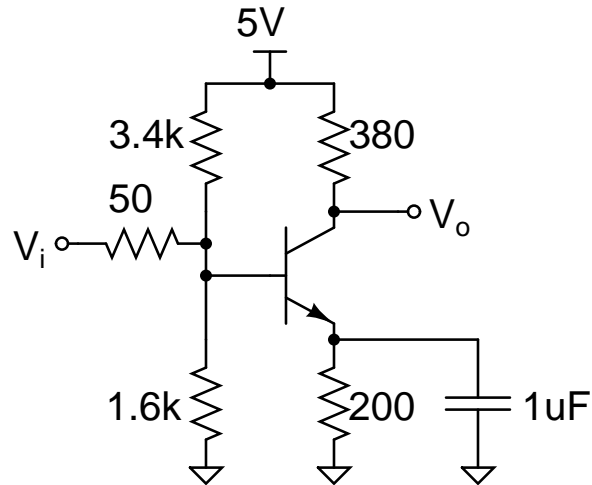


Problem 5: For the following transistor circuit, you are given $V_{BE} = 0.6 \text{ V}$, $\beta = 200$, and $V_A = 80 \text{ V}$. Find I_S for the large-signal model, and g_m , r_π , and r_o for the hybrid- π small-signal model. Also, draw the small-signal equivalent circuit.



Problem 6: You are given a transistor with the following parameters: $f_T = 1.4$ GHz and $c_\mu = 2$ pF at $I_C = 25$ mA and $V_{CE} = 12.6$ V. Additionally, you learn that $c_{jef} = 10$ pF, $\psi_c = 0.5$ V, $m_c = 0.5$, $\beta = 200$, $V_A = 50$ V, and $V_{BE} = 0.6$ V.

Find the small-signal model for the following circuit, including the values of c_π , c_μ , and r_o . Also, find the mid-band gain.



Problem 7: For the following circuit, find the transfer function $\frac{V_o}{I_i}(s)$

