Computer Simulation Problems

SIM Problems identified by the Multisim/PSpice icon are intended to demonstrate the value of using SPICE simulation to verify hand analysis and design, and to investigate important issues such as gain–bandwidth trade-off. Instructions to assist in setting up PSpice and Multisim simulations for all the indicated problems can be found in the corresponding files on the website. Note that if a particular parameter value is not specified in the problem statement, you are to make a reasonable assumption.

Section 10.1: Low-Frequency Response of Discrete-Circuit Common-Source and Common-Emitter Amplifiers

D 10.1 For the amplifier in Fig. 10.3(a), if $R_{G1} = 2\ \text{M}\Omega$, $R_{G2} = 1\ \text{M}\Omega$, and $R_{sig} = 200\ \text{k}\Omega$, find the value of the coupling capacitor C_{C1} (specified to one significant digit) that places the associated pole at 10 Hz or lower.

D 10.2 For the amplifier in Fig. 10.3(a), if $R_D = 10\ \text{k}\Omega$, $R_L = 10\ \text{k}\Omega$, and r_o is very large, find the value of C_{C2} (specified to one significant digit) that places the associated pole at 10 Hz or lower.

D 10.3 The amplifier in Fig. 10.3(a) is biased to operate at $g_m = 5$ mA/V, and $R_S = 1.8\ \text{k}\Omega$. Find the value of C_S (specified to one significant digit) that places its associated pole at 100 Hz or lower. What are the actual frequencies of the pole and zero realized?

10.4 The amplifier in Fig. 10.3(a) is biased to operate at $g_m = 5$ mA/V, and has the following component values: $R_{sig} = 100\ \text{k}\Omega$, $R_{G1} = 47\ \text{M}\Omega$, $R_{G2} = 10\ \text{M}\Omega$, $C_{C1} = 0.01\ \mu\text{F}$, $R_S = 2\ \text{k}\Omega$, $C_S = 10\ \mu\text{F}$, $R_D = 4.7\ \text{k}\Omega$, $R_L = 10\ \text{k}\Omega$, and $C_{C2} = 1\ \mu\text{F}$. Find $A_M, f_{P1}, f_{P2}, f_Z, f_{P3}$, and f_L.

D 10.5 The amplifier in Fig. P10.5 is biased to operate at $g_m = 2$ mA/V. Neglect r_o.

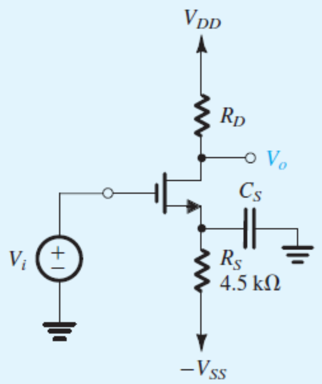

Figure P10.5

(a) Determine the value of R_D that results in a midband gain of −20 V/V.
(b) Determine the value of C_S that results in a pole frequency of 100 Hz.
(c) What is the frequency of the transmission zero introduced by C_S?
(d) Give an approximate value for the 3-dB frequency f_L.

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(e) Sketch a Bode plot for the gain of this amplifier. What does the plot tell you about the gain at dc? Does this make sense? Why or why not?

D 10.6 Figure P10.6 shows a CS amplifier biased by a constant-current source I. Let $R_{sig} = 0.5\ \text{M}\Omega$, $R_G = 2\ \text{M}\Omega$, $g_m = 3\ \text{mA/V}$, $R_D = 20\ \text{k}\Omega$, and $R_L = 10\ \text{k}\Omega$. Find A_M. Also, design the coupling and bypass capacitors to locate the three low-frequency poles at 100 Hz, 10 Hz, and 1 Hz. Use a minimum total capacitance, with the capacitors specified only to a single significant digit. What value of f_L results?

D 10.7 Figure P10.7 shows a current-biased CE amplifier operating at 100 μA from ±3-V power supplies. It employs

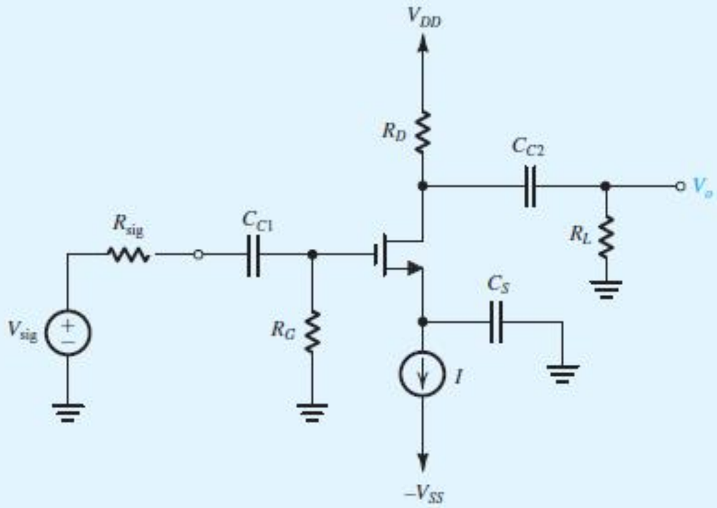

Figure P10.6

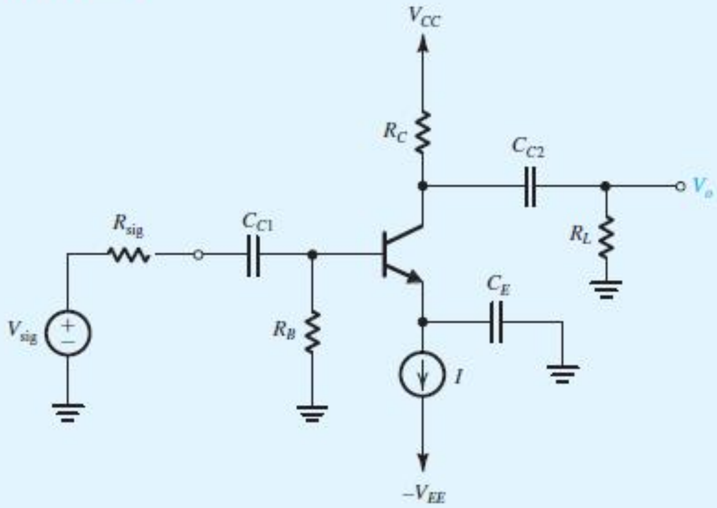

Figure P10.7

of 2 pF. If the device is operated at $I_C = 0.25$ mA, what does its f_T become?

10.20 An *npn* transistor is operated at $I_C = 1$ mA and $V_{CB} = 2$ V. It has $\beta_0 = 100$, $V_A = 50$ V, $\tau_F = 30$ ps, $C_{je0} = 20$ fF, $C_{\mu 0} = 30$ fF, $V_{0c} = 0.75$ V, $m_{CBJ} = 0.5$, and $r_x = 100\ \Omega$. Sketch the complete hybrid-π model, and specify the values of all its components. Also, find f_T.

10.21 Measurement of h_{fe} of an *npn* transistor at 50 MHz shows that $|h_{fe}| = 10$ at $I_C = 0.2$ mA and 12 at $I_C = 1.0$ mA. Furthermore, C_μ was measured and found to be 0.1 pF. Find f_T at each of the two collector currents used. What must τ_F and C_{je} be?

10.22 A particular small-geometry BJT has f_T of 10 GHz and $C_\mu = 0.1$ pF when operated at $I_C = 1.0$ mA. What is C_π in this situation? Also, find g_m. For $\beta = 120$, find r_π and f_β.

10.23 For a BJT whose unity-gain bandwidth is 2 GHz and $\beta_0 = 200$, at what frequency does the magnitude of h_{fe} become 40? What is f_β?

***10.24** For a sufficiently high frequency, measurement of the complex input impedance of a BJT having (ac) grounded emitter and collector yields a real part approximating r_x. For what frequency, defined in terms of ω_β, is such an estimate of r_x good to within 10% under the condition that $r_x \le r_\pi/10$?

***10.25** Complete the table entries on the previous page for transistors (a) through (g), under the conditions indicated. Neglect r_x.

Section 10.3: High-Frequency Response of the CS and CE Amplifiers

10.26 In a particular common-source amplifier for which the midband voltage gain between gate and drain (i.e., $-g_m R_L'$) is -39 V/V, the NMOS transistor has $C_{gs} = 1.0$ pF and $C_{gd} = 0.1$ pF. What input capacitance would you expect? For what range of signal-source resistances can you expect the 3-dB frequency to exceed 1 MHz? Neglect the effect of R_G.

D 10.27 In the circuit of Fig. P10.27, the voltage amplifier is ideal (i.e., it has an infinite input resistance and a zero output resistance).

(a) Use the Miller approach to find an expression for the input capacitance C_{in} in terms of A and C.
(b) Use the expression for C_{in} to obtain the transfer function $V_o(s)/V_{sig}(s)$.

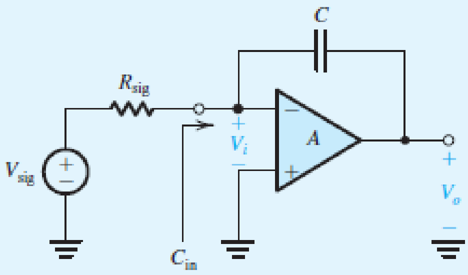

Figure P10.27

(c) If $R_{sig} = 1\ \text{k}\Omega$, and the gain V_o/V_{sig} is to have a dc value of 40 dB and a 3-dB frequency of 100 kHz, find the values required for A and C.
(d) Sketch a Bode plot for the gain and use it to determine the frequency at which its magnitude reduces to unity.

10.28 An ideal voltage amplifier having a voltage gain of –1000 V/V has a 0.2-pF capacitance connected between its output and input terminals. What is the input capacitance of the amplifier? If the amplifier is fed from a voltage source V_{sig} having a resistance $R_{sig} = 1\ \text{k}\Omega$, find the transfer function V_o/V_{sig} as a function of the complex-frequency variable s and hence the 3-dB frequency f_H and the unity-gain frequency f_t.

D 10.29 A design is required for a CS amplifier for which the MOSFET is operated at $g_m = 5$ mA/V and has $C_{gs} = 5$ pF and $C_{gd} = 1$ pF. The amplifier is fed with a signal source having $R_{sig} = 1\ \text{k}\Omega$, and R_G is very large. What is the largest value of R_L' for which the upper 3-dB frequency is at least 6 MHz? What is the corresponding value of midband gain and gain–bandwidth product? If the specification on the upper 3-dB frequency can be relaxed by a factor of 3, that is, to 2 MHz, what can A_M and GB become?

10.30 Reconsider Example 10.3 for the situation in which the transistor is replaced by one whose width W is half that of the original transistor while the bias current remains unchanged. Find modified values for all the device parameters along with A_M, f_H, and the gain–bandwidth product, GB. Contrast this with the original design by calculating the ratios of new value to old for W, V_{OV}, g_m, C_{gs}, C_{gd}, C_{in}, A_M, f_H, and GB.

D *10.31 In a CS amplifier, such as that in Fig. 10.3(a), the resistance of the source $R_{sig} = 100\ \text{k}\Omega$, amplifier

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