MICROELECTRONIC CIRCUIT DESIGN

Second Edition

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Answers to Selected Problems

(Updated versions of this file may be available at http://www.jaegerblalock.com)

Chapter 1

1.3 1.52 years, 5.06 years

1.5 2.00 years, 6.65 years

1.8 113 MW, 511 kA

1.10 2.44 mV, 5.71 V

1.12 19.53 mV/bit, 10001110_2

1.16 0.002 A, 0.002 cos (1000*t*) A

1.19 [5 + 2 sin (2500*t*) + 4 sin (1000*t*)] V

1.21 14.7 V, 3.30 V, 76.7 μA, 300 μA

1.23 150 μA, 100 μA, 8.20 V

1.25 40 Ω, 0.025 v_s

1.27 56 kΩ, 1.07×10^{-3} v_s

1.29 1.00 MΩ, $2.00 \times 10^8 i_s$

1.33 $5\angle -45°$, $100\angle -12°$

1.35 -90.1 sin 750πt mV, 11.0 sin 750πt μA

1.37 $1 + R_2/R_1$

1.39 -1.875 V, -2.500 V

1.41 Band-pass amplifier

1.43 25.0 sin (2000π*t*) + 15.0 cos (8000 π*t*) V

1.45 0 V

1.47 [1980Ω, 2020Ω], [1900Ω, 2100Ω], [1800Ω, 2200Ω]

1.52 6200Ω, 800 ppm/°C

1.58 3.29, 0.995, −6.16; 3.295, 0.9952, −6.155

Chapter 2

2.4 For Ge: $35.9/cm^3$, $2.27 \times 10^{13}/cm^3$, $8.04 \times 10^{15}/cm^3$

2.7 2.13×10^6 cm/s, 7.80×10^5 cm/s, 3.41×10^4 A/cm², 1.25×10^{-10} A/cm²

2.8 305.2 K

2.10 -5×10^4 cm/s

2.13 1.60×10^6 A/cm², 0.800 A

2.15 316.6 K

2.19 Acceptor, donor

2.20 100 V/cm

2.22 5×10^4 atoms

2.24 3.00×10^{16}/cm³, 3.33×10^5/cm³

2.28 2×10^{17}/cm³, 500/cm³, 2×10^{17}/cm³, 0.0227/cm³

2.30 3×10^{17}/cm³, 333/cm³

2.32 10^2/cm³, 10^{18}/cm³, 350cm²/V · s, 150cm²/V · s, 0.042 Ω · cm, *p*-type

2.34 10^{16}/cm³, 10^4/cm³, 710cm²/V · s, 260cm²/V · s, 2.40 Ω · cm, *p*-type

2.38 2.5×10^{15}/cm³

2.40 Yes—add equal amounts of donor and acceptor impurities. Then $n = n_i = p$, but the mobilities are reduced. See Prob. 2.26.

2.42 1.4×10^{17}/cm³

2.44 6.64 mV, 12.9 mV, 25.9 mV

2.46 $-12.0 \times 10^3 \exp(-5000x)$ A/cm²; -1.20 mA

2.48 (b) -553 A/cm², -603 A/cm², + 20 A/cm², -7 A/cm², +46.7 A/cm², -638 A/cm²

2.50 1.108 μm

Chapter 3

3.1 10^{18}/cm², 10^2/cm³, 10^{15}/cm³, 10^5/cm³, 0.748 V, 0.984 μm

3.3 0.806 V, 1.02 μm, 1.02 μm, 1.02×10^{-4} μm, 15.8 kV/cm

3.6 1.80 V, 3.06 μm

3.10 1600 A/cm²

3.13 5×10^{20}/cm⁴

3.17 290 K

3.20 312K

3.21 1.39, 3.17 pA

3.22 0.748 V; 0.691 V; 0 A; -0.909×10^{-17} A; -1.00×10^{-17} A

3.25 1.35 V; 1.38 V

3.28 0.518 V; 0.633 V

3.31 0.757 V; 0.721 V

3.34 -1.96 mV/K

3.37 0.576 V, 2.74 μm, 11.7 μm, 36.2 μm

3.39 374 V

3.41 4 V, 0 Ω

3.43 9.80 nF/cm^2; 37.6 pF

3.45 400 fF, 10 fC; 100 pF, 2.5 pC

3.49 13.9 MHz; 21.9 MHz

3.51 0.495 V, 0.725 V

3.53 0.708 V, 0.718 V

3.56 Load line: (450 μA, 0.500 V); SPICE: (443 μA, 0.575 V)

3.59 (0.600 mA, -4 V)

3.65 Load line: (51μA, 0.49 V); Mathematical model: (49.93μA, 0.5007 V); Ideal diode model: (100 μA, 0 V); CVD model: (40.0μA, 0.600 V)

3.69 (a) (0.500 mA, 0 V); (0.465 mA, 0.700 V)

3.71 (a) (-6.67 V, 0 A), (0 V, 1.67 mA); (-6.15 V, 0 A), (0.75 V, 1.62 mA)

3.73 **(a)** (1.00 mA, 0 V) (0 mA, -2 V) (1.00 mA, 0) **(d)** (0 A, -0.667 V) (0 mA, -1.33 V) (0.567 mA, 0 V)

3.76 (1.50 mA, 0 V) (0 A, -5 V) (1.00 mA, 0)

3.78 (I_Z, V_Z) = (343μA, 4.00 V)

3.81 12.6 mW

3.83 0.501 W, 3.50 W

3.88 0.975 $(V_P - V_{on})$

3.91 -7.91 V; 1.05 F; 17.8 V; 3530 A; 841 A (ΔT = 0.628 ms)

3.94 -7.91V, 0.158 F, 17.8 V, 3540 A, 839 A

3.97 3.33 F; 12 V; 4.24 V; 1540 A; 7530 A

3.100 7.91 V; 0.527 F; 16.8 V; 210 A; 1770 A

3.103 417 μF, 2000 V, 1414 V, 0.375 ms, 314 A

3.107 417 μF; 4000 V; 1410 V; 44.4 A; 314 A

3.114 $\delta = 2/3$; C = 74.1 μF ≅ 82 μF; L = 1.48 mH ≅ 1.5 mH

3.117 $V_O = \dfrac{V_S}{1-\delta} - V_{on}$; 6.75 V; 37.5 mV; 44.4 mA

3.118 $\eta = \dfrac{100\%}{1 + (1-\delta)\dfrac{V_{on}}{V_S}}$; 96.4%;

$$\eta = \frac{100\%}{1 + (1-\delta)\dfrac{V_{onD}}{V_S} + \delta\dfrac{V_{onS}}{V_S}}$$

3.121 $\delta = 0.300$; C = 2.08 μF ≅ 2.2 μF; L = 7.00 mH ≅ 6.8 mH

3.124 $V_O = V_S$□ □ V_{on}(1 □ □); 4.63 V; 116 mV; 46.3 mA; slightly reduced output voltage, <50 percent of ripple voltage and current

3.137 Slopes: 0, +0.5, 0.667; breakpoints: −2 V, 0 V

3.140 Slopes: +0.25, +0.5, +0.25, 0; breakpoints: 0 V, 2 V, 4 V

3.142 5 mA, 4.4 mA, 3.6 mA, 8.6 ns

3.146 (0.969 A, 0.777 V); 0.753 W; 1 A, 0.864 V

3.148 1.11 μm, 0.875 μm; far infrared, near infrared

Chapter 4

4.3 10.5 x 10^{-9} F/cm^2

4.4 34.5 μA/V^2, 86.3 μA/V^2, 173 μA/V^2, 345 μA/V^2

4.8 (a) 4.00 mA/V^2 (b) 4.00 mA/V^2, 8.00 mA/V^2

4.11 208 μA; −218 μA

4.15 93.0 Ω; 148 Ω

4.18 450 μA/V^2

4.20 13.6 A/V^2

4.22 125 μA/V^2; 1.5 V; enhancement mode; 5/1

4.26 57.5 μA, linear region; 195 μA, saturation region; 0 A, cutoff

4.27 saturation; cutoff; saturation; linear; linear; saturation

4.34 1.72 mA; 1.56 mA

4.37 2.26 mA, 4.52 mA, 2.48 mA

4.38 6.00 mA; 6.00 mA (our linear region model does not contain λ)

4.41 97.9 μA; 98.1 μA

4.44 31.5 μA; 28.8 μA

4.46 4.85 V

4.48 13.8 μA/V^2; 34.5 μA/V^2; 69.0 μA/V^2, 138 μA/V^2

4.51 5.00 μA; 9100 μA; 0.550 μA; 4.10 μA

4.54 235 Ω; 94.1 Ω; 250/1

4.57 0.629 A/V^2

4.60 0.360 μA

4.62 $V_{TN} > 0$; depletion mode; no

4.71 1.73×10^{-7} F/cm^2; 4.32 fF

4.74 8.63 nF

4.81 (1.12 mA, 1.75 V); linear region

4.84 (70.2 μA, 9.47 V)

4.86 (42.3 μA, 9.00 V)

4.91 134 μA; 116 μA

4.94 510 kΩ, 470 kΩ, 12 kΩ, 12 kΩ 20/1

4.97 (124 μA, 2.36 V)

4.100 (32.5 μA, 1.26 V)

4.103 (23.0 μA, 1.12 V)

4.107 (58.3 μA, 9.20 V)

4.111 (227 μA, 3.18 V)

4.112 4.52 mA; 10.8 mA

4.114 (9/10) = 1.11/1

4.116 (a) (124 μA, 5.70 V) (b) (182 μA, 1.34 V)

4.118 4.04 V, 2.71 mA, 10.8 mA

4.119 3.61 mA; 6.77 mA; 2.61 mA

4.121 (59.8 μA, 6.03 V), 138 kΩ

4.126 (a) (98.4 μA, 2.15 V)

4.130 341 kΩ

4.133 (200 μA, 13 V)

4.137 (36.3 μA, 12.9 mV); (31.7 μA, 1.54 V); (28.2 μA, 2.69 V)

4.140 44.3 kΩ, $V \geq 5$ V

4.143 1.52 V, 0.77 V

4.149 34.5 fF, 17.3 fF

4.154 (500 μA, 5.00 V); (79.9 μA, 0.250 V); (159 μA, 3.70 V)

4.156 2.50 kΩ; 10.0 kΩ

4.157 0.5 mA, 0, 1.17 V; 1.38 mA, 0.62 mA, −0.7 V

4.160 (69.5 μA, 3.52 V); (131 μA, 3.52 V)

4.162 (69.5 μA, 5.05 V); (456 μA, 6.20 V))

Chapter 5

5.4 0.0167, 0.667, 3.00, 0.909, 49.0, 0.9950, 0.9990, 5000

5.5 2 fA; 1.01 fA, −0.115 V

5.9 2.02 fA

5.11 1.07 mA; −1.07 mA

5.14 0.599 V

5.17 0.606 V

5.20 723 μA

5.20 723 μA

5.28 979 μA, 930 μA, 48.9 μA

5.35 saturation, forward-active region, reverse-active region, cutoff

5.39 83.3, 87.5, 100

5.46 21.5 mV, 25.8 mV, 30.2 mV

5.48 2.31 mA; 388 □A; 0

5.52 12 fF; 1.2 pF; 120 pF

5.54 600 MHz, 3 MHz

5.56 0.282 □m

5.59 I_C = 16.3 pA, I_E = 17.1 pA, I_B = 0.857 pA, forward-active region; although I_C, I_E, I_B are all very small, the Transport model still yields I_C □ □$_F I_B$

5.61 50, 1.73 fA

5.63 6.25 MHz

5.65 0.500, 17.3 aA

5.67 □23.7 □A, +31.6 □A, □55.3 □A

5.69 $v_{EC\text{SAT}}$ is identical to Eq. (5.46)

5.73 0.812 V, 0.730 V

5.75 71.7, 43.1 V

5.77 100 □A, 4.52 □A, 95.5 □A, 0.589 V, 0.593 V, 0.592 V; 2.19 mA, 0.100 mA, 2.09 mA, 0.666 V, 0.666 V

5.82 (80.9 □A, 3.80 V); (404 □A, 3.80 V)

5.86 (42.2 □A, 4.39 V)

5.92 (7.8 mA, 4.1 V)

5.94 (5.0 mA, 1.3 V)

5.96 56 k□ (or 62 k□), 1.5 M□; 12.4 □A, 0.799 V

5.100 101 □A, 98.4 □A

5.107 5.24 V

5.109 3.21 □

5.112 60.7 □A, 86.0 □A, 4.00 V, 5.95 V

5.116 4.4 percent; 70 percent

5.118 4.74 mA, 9.71 mA, 1.28 V, 3.73 V

Chapter 6

6.1 10 □W/gate, 2 □A

6.3 5 V, 0 V, 0 W, 0.25 mW; 3.3 V, 0 V, 0 V, 0.11 mW

6.5 V_{OL} = 0 V, V_{OH} = 3.3 V, V_{REF} = 1.1 V; $Z = A$

6.7 3 V, 0 V, 2 V, 1 V, □3

6.9 2 V, 2 V, 3 V, 2 V

6.11 3.3 V, 0 V, 1.8 V, 1.5 V, 1.5 V, 1.5 V

6.13 □0.78 V, □1.36 V

6.15 1 ns

6.17 5 □W, 1.52 □A, 5 fJ

6.19 2.20 RC; 2.20 RC

6.21 −0.78 V, −1.36 V, 0.5 ns, 0.5 ns, 8 ns, 9 ns, 4 ns, 4 ns

6.24 Z = 0 0 0 1 0 0 1 1

6.26 Z = 0 1 0 1 0 1 0 1

6.29 2; 1

6.31 $Z = AB$; $Z = A + B$

6.33 16.2

6.35 $Y = \overline{ABC}$

6.37 V_{REF} = 2.8 V

6.41 0.583 pF

6.44 20 μW/gate, 4 μA/gate

6.49 0.984 V, 3.13 V

6.53 40.3 kΩ; 4.90/1; 1.47 V, 0.653 V

6.56 1000 Ω; 2500 Ω; a resistive channel exists connecting the source and drain; 20/1

6.59 1.83 V

6.62 0.774 V, 0.610 V

6.66 3.74/1, 1/1.41

6.69 0.190 V

6.71 ratioed logic so V_{OH} = 3.39 V, V_{OL} = 0.25 V; P = 0.18 mW

6.77 6.80 V

6.81 1.89

6.83 4.90/1, 1/1.41, 0.777 V, 1.36 V

6.85 2.33/1, 1/1.55

6.90 3.53/1, 1/3.39

6.94 $Y = \overline{(A + B)(C + D)(E + F)}$, 6.18/1, 1/2.15

6.98 $Y = \overline{ACE + ACDF + BF + BDE}$, 1.40/1, 24.7/1, 16.5/1

6.101 1/4.30, 3.09/1

6.104 $Y = \overline{(C + E)[A(B + D) + G] + F}$; 1/1.08, 4.12/1, 6.18/1, 12.4/1

6.107 3.15/1, 6.06/1, 6.24/1, 6.42/1

6.110. +5 V, 0.163 V

6.113 1.85/1, 8.24/1, 12.4/1, 24.8/1

6.118 $I'_{DS} = 2I_{DS}$, $P'_D = 2P_D$

6.121 1 ns

6.123 60.2 ns, a potentially stable state exists with no oscillation

6.124 105 ns, 6.23 ns, 17.9 ns

6.128 192 ns, 4.44 ns, 11.8 ns

6.136 2.63/1, 25.3/1, 13.6 ns, 2.07 ns

6.142 (a) 1/3.39 (d) 1/9.20 (f) 1/2.25

6.146 −4.00 V, −0.300 V

6.148 1.28/1, 7.09/1

6.150 1.61 V, 4.68 V

6.152 $Y = \overline{A + B}$

Chapter 7

7.1 27.7 $\mu A/V^2$; 11.1 $\mu A/V^2$

7.3 250 pA; 450 pA; 450 pA

7.6 3.3 V, 0 V

7.8 cut off, triode, triode, triode, saturation, saturation

7.11 2.5 V; 2.16 V

7.13 2.1628 V, 2.16 V

7.15 27.0/1, 1/1.17

7.17 2.57 V, 1.70 V; 1.69 V, 1.17 V

7.21 1.61 ns, 3.22 ns

7.23 2.18 ns, 4.36 ns

7.25 4.33/1, 10.8/1

7.27 7.11/1, 17.8/1

7.29 2.2 ns, 2.3 ns, 1.2 ns, 1.1 ns, $\langle C \rangle = 177$ fF

7.31 2 μW/gate, 16.0 fF, 36.7 fF

7.34 4 W; 1.74 W

7.36 22.6 μA; 2.25 μA

7.41 □□T, □^{2}P, □^{3}PDP

7.46 5/1, 8/1; 15/1, 24/1

7.50 3.2/1, 2/1

7.56 8.13 ns, 8.13 ns, 8.13 ns

7.57 (a) 5 transistors

7.59 $Y = \overline{(A + B)(C + D)E} = \overline{ACE + ADE + BDE + BCE}$, 15/1, 18/1, 30/1

7.61 4/1, 15/1

7.63 4/1, 6/1, 10/1

7.65 20/1, 24/1, 40/1

7.72 11 1 ns, 2.6 ns

7.74 19.5 ns, 48.8 ns

7.79 V_{DD} □ $\frac{2}{3}V_{DD}$ □ $\frac{1}{2}V_{DD}$; $R \geq \frac{2V_{IH}}{V_{DD} - V_{IH}} = \frac{2V_{IH}}{NM_H}$, $C_1 \geq 2.88C_2$

7.85 N = 6, A = 462 A_o

7.87 500 Ω, 1250 Ω

7.89 ≅ 160/1

7.94 $N_{ML} = \dfrac{V_{DD} + 3V_{TN} + V_{TP}}{4}$ | $N_{MH} = \dfrac{V_{DD} - V_{TN} - 3V_{TP}}{4}$

Chapter 8

8.1. 268,435,456 ; 1,073,741,824

8.2. 3.73 pA

8.5 2.67 μV

8.10. "1" level is discharged by junction leakage current

8.12. −19.8 mV; 2.48 V

8.16. 1.60 V, +5.00 V; −1.83 V

8.18 58.5 mW

8.21. 361 μA, 1.85 W

8.23. 0.266 V

8.24. 0.95 V

8.31. 11,304; 11,304

8.35. $V_{DD} \rightarrow \frac{2}{3}V_{DD} \rightarrow \frac{1}{2}V_{DD}$; $R \geq \dfrac{2V_{IH}}{V_{DD} - V_{IH}} = \dfrac{2V_{IH}}{NM_H}$

8.37. $W_3 = 00101011_2$

8.42. 1.16/1

Chapter 9

9.1 1.38 V, 1.12

9.3 −1.75 V, 0 V

9.5 −1.0 V, −1.4 V, −1.2 V, 132 mV, 10.4 mW

9.9 −0.700 V, −1.70 V, −1.20 V, 1.00 V

9.11 −0.700 V, −1.50 V, −1.10 V, 2.67 kΩ; 0.314 V, −0.100 V, +0.300 V

9.12 53.3 μA

9.15 4.20 kΩ, 1.17 kΩ, 200 Ω, 185 Ω

9.17 0.324 V

9.21 0.340 V

9.23 50.0 μA, -2.30 V

9.25 9.25 kΩ, 10.0 kΩ, 58.5 kΩ, 210 kΩ

9.28 +0.600 V, −0.560 V, 314 Ω

9.31 5.15 mA

9.34 0.13 mA

9.38 500 Ω, 60.0 mA

9.40 (c) 0 V, -0.7 V, 3.93 mA (d) –3.7 V, 0.982 mA (e) 2920 Ω

9.43 $Y = A + \overline{B}$

9.47 −0.892 V; −1.14 V

9.51 −1.00 V; −0.974 V; −0.948 V; −0.922 V

9.55 23.2 μA

9.57 −0.850 V; 3.59 pJ

9.59 0 V, −0.600 V, 5.67 mW; $Y = A + B + C$, $Y = \overline{A + B + C}$, 5 vs. 6

9.62 5.00 kΩ, 5.40 kΩ, 31.6 kΩ, 113 kΩ

9.65 2.23 kΩ, 4.84 kΩ, 120 kΩ

9.67 2.98 pA, 74.5 fA

9.69 160; 0.976; 5; 0.773 V

9.70 0.691 V, 0.710 V

9.75 40.2 mV, 0.617 mV

9.77 3 V, 0.15 V, 0.66 V, 0.80 V, 33

9.79 0.682 V, 2.47 mA

9.83 44.8 kΩ, 22.4 kΩ

9.85 5 V, 0.15 V, 0; −1.06 mA, 31; −1.06 mA vs. −1.01 mA, 0 mA vs. 0.2 mA

9.93 8

9.95 234 mA, 34.9 mA

9.99 (I_B, I_C): (a) (135 μA, −169μA); (515μA, 0); (169 μA, 506 μA); (0, 0) (b) all 0 except $I_{B1} = I_{E1} =$ 203 μA

9.105 1.85 V, 0.15 V; 62.5 μA, −650 μA; 13

9.107 $Y = \overline{ABC}$; 1.9 V; 0.15 V; 0, −408 μA

9.109 1.5 V, 0.25 V; 0, −1.00 mA; 16

9.111 963 μA, 963 μA, 0

9.116 (I_B, I_C): (532μA, 0); (0, 0); (0, 0); (3.75 μA, 150 μA)

9.120 $Y = A + B + C$; 0 V, −1.0 V; −0.90 V

9.121 $Y = A + B + C$; 0 V, −0.80 V; −0.40 V

Chapter 10

10.3 Using MATLAB:

```
t = linspace(0,.004);
vs = sin(1000*pi*t)+0.333*sin(3000*pi*t)+0.200*sin(5000*pi*t);
vo= 2*sin(1000*pi*t+pi/6)+sin(3000*pi*t+pi/6)+sin(5000*pi*t+pi/6); plot(t,vs,t,vo)par
```

500 Hz: 1 0°, 1500 Hz: 0.333 0°, 2500 Hz: 0.200 0°; 2 30°, 1 30°, 1 30° 2 30°, 3 30°, 5 30° yes

10.5 35.0 dB, 111 dB, 73.2 dB

10.8 12.7, 2.00×10^5, 1.59×10^4

10.12 −10 (20 dB), 0.1 V

10.14 8 − sin (1000*t*); there are only two components; dc: 8 V, 159 Hz: −4 V

$$\left(g_{12} - \frac{g_{11}g_{22}}{g_{21}}\right)^{-1} \approx -\frac{g_{21}}{g_{11}g_{22}}; \quad \left(g_{22} - \frac{g_{21}g_{12}}{g_{11}}\right)^{-1} \approx \frac{1}{g_{22}};$$

10.17 11.2%

10.21 10 kΩ, 1, −101, 4.17 μS

10.23 24.3 MΩ, 240 kΩ, 24.2 MΩ, 240 kΩ

10.26 102 kΩ, 0.0164, 98.3, 16.4 μS

10.28 3.50 kΩ, 1.00 kΩ, −6.00 MΩ, 61.0 kΩ

10.30 1 mS, −1, 2001, 20 kΩ

10.32 0.101 S, 50.0 μS, −0.100 S, 50.0 μS

10.35 $y_{11} - \dfrac{y_{12}y_{21}}{y_{22}} \approx y_{11}; \ \dfrac{y_{12}}{y_{22}} \approx 0; \ -\dfrac{y_{21}}{y_{22}}; \ \dfrac{1}{y_{22}}$

10.37 $\left(g_{11} - \dfrac{g_{12}g_{21}}{g_{22}}\right)^{-1} \approx \dfrac{1}{g_{11}}; \ \left(g_{21} - \dfrac{g_{22}g_{11}}{g_{12}}\right)^{-1} \approx 0;$

10.41 45.3 mV; 1.00 W

10.45 −8180

10.47 0, , 125 mW,

10.50 -3.52 dB, 23.9 kHz

10.54 -0.828 dB, 145 Hz

10.57 60 dB, 10 kHz, 10 Hz, 9.99 kHz, band-pass amplifier

10.59 80 dB, , 50 Hz, , high-pass amplifier

10.62 28.3 Hz, 100 kHz

10.69 0.477 sin (10π*t* + 63.4°) V, 0.999 sin (1000π*t* − 1.72°) V, 0.477 sin (10^5π*t* − 78.7°) V

10.71 0.06 sin (2π*t* + 88.9°) V, 2.12 sin (100π*t* + 45.0°) V, 3.00 sin (10^4π*t* + 0.57°)V

10.75 $\dfrac{10^8\pi}{s + 10^7\pi}; \ -\dfrac{10^8\pi}{s + 10^7\pi}$

10.78 12.8 kHz, -60 dB/decade

10.79 10 sin (1000π*t* + 10°) + 3.33 sin (3000π*t* + 30°)+ 3.00 sin (5000π*t* + 50°) V; Using MATLAB:

```
t = linspace(0,.004);
vs = sin(1000*pi*t)+0.333*sin(3000*pi*t)+0.200*sin(5000*pi*t);
vo = 10*sin(1000*pi*t+pi/18)+3.33*sin(3000*pi*t+3*pi/18)+2.00*sin(5000*pi*t+5*pi/18);
plot(t, 10*vs, t, vo)
```

Chapter 11

11.1 79.9 dB, 120 dB, 89.9 dB; 5.05 mV

11.3 ≥ 4.95 M□

11.5 0.100 mV, 140 dB

11.7 (a) □46.8, 4.7 k□, 0, 33.4 dB

11.10 83.9, , 0, 83.9 dB

11.13 (0.510 sin 3770*t* □1.02 sin 10000*t*) V, 0

11.15 □10, 110 k□, 10 k□

11.18 -12, (-6 + 1.2sin4000□t) V

11.22 (a) 79.6 pF (b) 82 pF, 19.4 kHz

11.26 □5.00, 20.0 k□; +6.00, 27.0 k□, 0, 33.0 k□ (not a useful circuit)

11.30 0.484 A; 0.730 V; 0.730 V; ≥ 7.03 W (choose 10 W), 7.27 W

11.33 $\frac{v_1 \,\square\, v_2}{R}$; ; $R(1 + A)$

11.35 3.99 V, 3.99 V, 1.99 V, 1.99 V, 3.99 V, 199 □A; □5 M□

11.37 3.6 k□, 49.6 k□

11.39 □1.20 V; □1.80 V; 0 to □3.00 V in 0.20-V steps

11.40 *A* and *B* taken together, *B* and *C* taken together

11.43 48.0, ∞, 0

11.47 -100, 8.62 k□, 0

11.50 785 M□, 3.75 m□

11.56 Noninverting to achieve R_{IN} with an acceptable value for resistor R_2: R_{OUT} can be met; R_{IN} is not achievable

11.58 □16.2 v_S, 85.9 m□

11.60 0.25 percent

11.62 60 dB

11.67 0.500 sin 5000□*t*, 10 sin 120□*t*; □10, □0.037; 48.6 dB; □5.00 sin 5000 □*t* □0.370 sin 120□*t*

11.71 □26.0 mV, 0, □26.0 mV, yes, 90.9 k□

11.74 A_V = 10,000 [$u(v_{ID}$ + 0.0005) □ $u(v_{ID}$ □ 0.0015)]

11.76 10.1 k□, 1.00 M□

11.77 □0.460 V; □0.546 V; □18.7 percent

11.79 10.0 V, 0 V; 15.0 V, 0.125 V

11.81 One possibility: 1 k□, 20 k□

11.87 $\left(1 + \frac{R_2}{R_1}\right)\frac{sC(R_1 \| R_2) + 1}{sCR_2 + 1}$

11.89 3 stages: 1 k□, 20 k□, 200 pF

11.94 $A_V(s) = \square\frac{3.653 \,\square\, 10^{13}}{s^2 + 3.142 \,\square\, 10^7 s + 1.916 \,\square\, 10^{12}}$; bode (□3.65*e*13,[13,142*e*7 1.916e12])

11.97 20 kΩ, 200 kΩ, 796 pF

11.98 −20, 143 kHz; 78.1 dB, 72.9 kHz

11.101 Two stages

11.105 6.91, 145 kHz, [6.35, 7.53], [133 kHz, 157 kHz]

11.107 1.89 V/μs

11.109 10 V/μs

11.110 250 kΩ, 1 kΩ, 2.55 μF, 8×10^4, 50 Ω; add two 10^9 Ω resistors

11.116 200,000, 10^{12} Ω, 1 kΩ, unspecified, 12.7 μF

11.118 0.010 μF, 0.005 μF, 1.13 kΩ, 20.0 kHz; 0.005 μF, 0.0025 μF

Chapter 12

12.1 (a) 0.005 μF, 0.01 μF, 1.13kΩ, 1, 20 kHz

12.5 $\dfrac{K}{s^2 R_1 R_2 C_1 C_2 + s[R_1 C_1(1 - K) + C_2(R_1 + R_2)] + 1}; \dfrac{K}{3 - K}$

12.7 −1; −1

12.11 1 kΩ, 100 kΩ, 0.0159 μF

12.13 1 rad/s, 0.0640 rad/s, 15.6; $\left(\dfrac{20}{s^2 + 0.1s + 1}\right)$

12.15 5.48 kHz, 1.34 kHz, 4.05, 63.1 dB

12.18 0

12.21 (0, T/2): 0 V, (T/2, 3T/2): 1 V, (3T/2, 5T/2): 4 V, (5T/2, 7T/2): 8 V, (7T/2, 9T/2): 12 V, (9T/2, 5T): 15 V

12.24 12.6 kHz, 1.58, 7.96 kHz

12.27 −1.125 V; −1.688 V; $n \times (-0.1875)$ V

12.30 000: 0, 001: 0.1220, 010: 0.2564, 100: 0.5000; 0.0716 LSB, 0.0434 LSB; 0.376 LSB, 0.188 LSB

12.33 1.43 percent, 2.5 percent, 5 percent, 10 percent

12.35 −0.3125 V, −0.6250 V, −1.250 V, −2.500 V

12.37 1.0742 kΩ, 0.188 LSB, 0.094 LSB; 1.2929 kΩ, 0.224 LSB, 0.417 LSB

12.40 (a) $(2^{n+1}-1)C$ (b) $(3n+1)C$

12.43 −2.500 V, −1.875 V, −1.250 V, −0.625 V, 0 V, +0.625 V, 1.250 V, +1.875 V

12.45 (3.415468 V, 3.415781 V)

12.49 0001011111, 95 μs

12.51 167 ns

12.53 $RC \geq 0.0448$ s; v_O (200 ms) = 22.32 V

12.55 For $\omega = 0$, $\dfrac{V_M T_T}{RC}\left[\dfrac{\sin \omega T_T}{\omega T_T}\right]$

12.57 $-V_1 V_2 / (10^4 I_s)$

12.59 0.759 V

12.60 2.40 Hz

12.65 2.38 V, 2.62 V, 0.240 V

12.67 0.487 V, −0.487 V, 0.974 V

12.70 0 Hz

12.73 841 μs, 416 μs

Chapter 13

13.1 0.700 + 0.005 sin $2000\pi t$ V; 1.03 sin $2000\pi t$ V; 5.00 −1.03 sin $2000\pi t$ V; 2.82 mA

13.3 Bypass, coupling, coupling; 0 V

13.6 Coupling, bypass, coupling; 0 V

13.9 Coupling, coupling, coupling

13.12 Coupling, coupling

13.14 (1.78 mA, 6.08 V)

13.16 (98.4 μA, 4.96 V)

13.20 (82.2 μA, 6.04 V)

13.24 (307 μA, 3.88 V)

13.28 (338 μA, 5.40 V)

13.32 (1.00 mA, 7.50 V)

13.42 Thévenin equivalent source resistance, gate-bias voltage divider, gate-bias voltage divider, source-bias resistor—sets source current, drain-bias resistor—sets drain-source voltage, load resistor

13.45 11.3 μA, 50 mV

13.48 (188 μA, $V_{CE} \geq 0.7$ V), 7.52 mS, 532 kΩ

13.51 (1.88 μA, $V_{CE} \geq 0.7$ V), 75.0 μS, 53.3 MΩ

13.53 (b) +16.7%, -13.6%

13.54 90, 120; 95, 75

13.58 −120

13.60 Yes, using $I_C R_C = (V_{CC} + V_{CE})/2$

13.62 2.5 mA; 30.7 V

13.64 −314, −314

13.66 −95

13.67 (−95.0, −94.1)

13.71 3

13.74 1.25 A

13.77 10%, 20%

13.80 Virtually any desired Q-point

13.81 (156 μA, 9 V)

13.87 400 = 133,000i_P + v_{PK}; (1.4 mA, 215 V); 1.6 mS, 55.6 kΩ, 89, −62.7

13.88 FET

13.91 111 μA, 1400

13.94 Yes, it is possible although the required value of $V_{GS} - V_{TN}$ (6.70 V) is getting rather large

13.97 0.5 V, (125 μA, 7.5 V)

13.98 2.5 V, 25 V

13.100 3

13.102 −10.9

13.105 −7.27

13.110 833 μA

13.112 33.3 kΩ, 94.4 kΩ

13.115 647 Ω, 3.62 kΩ

13.116 (b) 1 MΩ, 0, −7.45 MΩ, 3.53 MΩ

13.118 6.8 MΩ, 45.8 kΩ

13.120 10 MΩ, 508 kΩ

13.122 1 MΩ, 6.82 kΩ

13.125 −15.0 v_S, 45.8 kΩ

13.129 −60.7, 630 Ω, 960 Ω; gain reduced by 25 percent due to lower input resistance

13.131 62.9 kΩ, 96.0 kΩ, -64.4

13.133 50 mA/V^2, 842 kΩ

13.139 1.38 μW, 0.581 mW, 0.960 mW, 0.887 mW, 2.43 mW

13.143 0.497 mW, 0.554 mW, 2.07 mW, 24.6 μW, 24.6 μW, 5.58 mW

13.146 V_{CC}/15

13.147 3.38 V, 13.6 V

13.150 32.9 μA, 2.30 V

13.152 356 μA, 2.02 V

13.153 500 μA, 1.76 V

Chapter 14

14.1 (a) C-C, (b) not useful, (h) C-B, (o) C-D

14.8 −5.00, , 20.0 kΩ, ; −10.0, , 10.0 kΩ,

14.10 (a) −6.91 (e) −120

14.11 6.58 kΩ, 66.7 kΩ

14.16 −120, −60.9, 2.83 kΩ, 8.20 kΩ, 6.76 mV

14.17 −14.7, −11.6, 368 kΩ, 75 kΩ, 183 mV

14.19 −3.07, 84.9, 1.00 MΩ, 39.0 kΩ, 1.49 V

14.24 0.909, , 100 Ω,

14.27 0.982, 1.29, 31.6 kΩ, 9.19 Ω, 2.83 V

14.28 0.956, 969, 1.00 MΩ, 555 Ω, 628 V

14.30 $(0.005 + 0.2\ V_{R4})$ V

14.33 48.8, 2.00 kΩ, , 1; 14.3, 2.00 kΩ, , 1

14.34 48.8, 1.98 kΩ, 4.92 MΩ, 1; 23.7, 1.98 kΩ, 10.1 MΩ, 1

14.38 5.51, 0.178, 2.73 kΩ, 24.0 kΩ, 0.398 V

14.39 36.5, 0.274, 252 Ω, 39.0 kΩ, 14.9 mV

14.43 44.5 Ω

14.45 632 Ω

14.47 $(\beta_o + 1)r_o = 153$ MΩ

14.48 $A_v = 398$ with $R_{in} = 1$ MΩ: A C-E amplifier operating at low current should be able to achieve both high A_v and high R_{in}. It would be difficult to achieve $A_V = 52$ dB with an FET stage.

14.51 A follower has a gain of approximately 0 dB. The input resistance of a C-C amplifier is approximately $(\beta_o + 1)R_L \cong 101(10\ \text{k}\Omega) = 1\ \text{M}\Omega$. Therefore a C-D stage would be preferred to achieve the gain of approximately 1 with $R_{in} = 25$ MΩ.

14.52 A noninverting amplifier is needed. Either the C-B or C-G amplifier should be able to achieve $A_V = +10$ with $R_{in} = 2$ kΩ with proper choice of the Q-point.

14.55 1.66 Ω

14.59 $\mu_f v_s,\ R_5 + r_o(1 + g_m R_5) \cong r_o(1 + g_m R_5)$

14.61 $v_s,\ (R_{th} + r_\pi)/(\beta_o + 1)$

14.63 **(a)** $z_{21} = R_B \dfrac{(\beta_o+1)R_E}{r_\pi + (\beta_o+1)R_E} \cong R_B \quad z_{12} = \dfrac{R_B R_E}{R_B + r_\pi + (\beta_o+1)R_E} \cong \dfrac{R_B}{(\beta_o+1)} \quad \dfrac{z_{21}}{z_{12}} \cong \beta_o + 1$

14.65 **(a)** $g_{21} = +g_m R_D \qquad g_{12} = \dfrac{R_D}{R_D + r_o} \cong \dfrac{R_D}{r_o} \qquad \dfrac{g_{21}}{g_{12}} \cong g_m r_o = \mu_f$

14.68 $(1/g_m)(1 + R_L/r_o)$ for $\mu_f >> 1$

14.69 −0.984, 0.993, 0.703 V

14.72 SPICE: (106 μA, 7.14 V), −14.2, 369 kΩ, 65.8 kΩ

14.74 SPICE: (9.81 μA, 5.74 V), 0.983, 11.0 MΩ, 2.58 kΩ

14.78 SPICE: (268 μA, 8.60 V), 4.26, 1.27 kΩ, 18.8 kΩ

14.79 SPICE: (5.59 mA, 5.93 V), −3.27, 10.0 MΩ, 1.53 kΩ

14.81 SPICE: (3.84 mA, 10.0 V), 0.953, 1.00 MΩ, 504 Ω

14.83 (a) 0.01 μF, 270 μF, 0.15 μF, (b) 2.7 μF

14.86 (a) 0.50 μF, 0.68 μF

14.89 (a) 8200 pF, 820 pF (b) 0.042 μF, 1800 pf, 0.015 μF

14.91 33.3 mA

14.93 $R_1 = 120$ kΩ, $R_2 = 110$ kΩ

14.95 The second MOSFET

14.97 $A_v^{max} = 54.8$, $A_v^{min} = 44.8$ beyond the Monte Carlo results by approximately 2 percent of nominal gain.

14.101 Voltage is not sufficient—transistor will be saturated.

14.105 95.2, 1000 Ω, ∞, 1; A_v is 2 × larger, R_{in} is 2 × smaller

Chapter 15

15.1 4.12, 1 MΩ, 64.3 Ω

15.2 4.44

15.5 2.19

15.7 711, 8.29 kΩ, 401 Ω

15.10 466, 73.8 kΩ, 20 kΩ

15.16 (a) (5.00 mA, 10.3 V), (1.88 mA, 3.21 V), (2.47 mA, 6.86 V) (b) (5.00 mA, 9.45 V), (2.38 mA, 0.108 V), (3.15 mA, 4.60 V) Q_2 is saturated! The circuit will no longer function properly as an amplifier.

15.17 (a) (325 μA, 7.14 V), (184 μA, 7.85 V), 86.1 dB

15.20 (a) (50.0 μA, 1.58 V), (215 μA, 13.2 V), −63.2, 1 MΩ, 1.91 kΩ

15.22 (a) (223 μA, 2.87 V), (1.96 mA, 5.00 V), −218, 7.61 kΩ, 241 Ω (b) −1.49, 75.6 kΩ

15.25 (a) (4.44 μA, 1.40 V), (23.3 μA, 2.30 V) (b) (4.08 μA, 1.42 V), (23.6 μA, 2.28 V)

15.27 4.05 MΩ, 2.00 mS, 553 kΩ, 77.2 pS

15.30 3.28 MΩ, 2.50 mS, 640 kΩ, 8190, 1600

15.35 $I_{C2} = \alpha_F I_{C1}$, $g_m' = g_m$, $r_\pi' = \beta_o r_\pi$, $r_o' = \frac{r_o}{2}$, $\beta_o' = \beta_o(\beta_o + 1)$, $\mu_f' = \frac{\mu_f}{2}$

15.38 $I_{C2} = \alpha_F I_{C1}$, $g_m' = g_m$, $r_\pi' = \beta_o r_\pi$, $r_o' = r_o$, $\mu_f' = \mu_f$

15.42 (8.52 μA, 1.42 V), (8.40 μA, 0.940 V), −48.1, cascode amplifier

15.43 (a) (20.7 μA, 5.87 V) (b) −273, 243 kΩ, 660 kΩ (c) −0.604, 47.1 dB, 27.3 MΩ

15.46 (a) (8.43 μA, 1.36 V) (b) −33.7, −1.02 kΩ, ∞ for differential output, 24.4 dB for single-ended output, 594 kΩ, 200 kΩ, 4.90 MΩ, 50 kΩ

15.48 R_{EE} = 1.1 MΩ, R_C = 1.0 MΩ

15.50 (200 μA, 4.90 V); differential output: −312, 0, ∞; single-ended output: −155, −0.0965, 64.2 dB; 25.0 kΩ, 40.4 MΩ, 78.0 kΩ, 39.0 kΩ

15.52 1.00 μA, 2.02 μA, 2.50 GΩ

15.54 V_O = 1.09 V, v_o = 0; V_O = 1.09 V, v_o = 219 mV; 5.00 mV

15.56 (47.4 μA, 6.23 V); Differential output: −379, 0, ∞; single-ended output: −190, −0.661, 49.2 dB; 158 kΩ, 22.7 MΩ

15.60 −16.1 V, −13.1 V, −3.00 V

15.61 −283, 4.94×10^{-3}, 95.2 dB

15.66 (24.2 μA, 5.36 V); A_{dd} = −45.9, A_{cc} = −0.738, differential CMRR = , single-ended CMRR = 24.7 dB, ,

15.69 (91.3 μA, 12.9 V); A_{dd} = −16.7, A_{cc} = −0.486, differential CMRR = , single-ended CMRR = 25.1 dB, ,

15.74 (150 μA, 7.60 V); A_{dd} = −26, A_{cc} = −0.233, differential CMRR = , single-ended CMRR = 34.9 dB, ,

15.77 (142 μA, 7.27 V); A_{dd} = −21.7, A_{cc} = −0.785, differential CMRR = , single-ended CMRR = 22.9 dB, ,

15.79 (20.0 μA, 6.67 V); A_{dd} = −26.8, A_{cc} = −0.119, differential CMRR = , single-ended CMRR = 41.0 dB, ,

15.80 −3.08 V, −1.22 V, 62.1 mV

15.83 (99.0 μA, 10.8 V); A_{dd} = −30.1, A_{cc} = −0.165, 553 kΩ

15.86 (400 μA, 1.71 V), (100 μA, -2.82 V), -26.8, 0, ∞

15.88 (24.8 μA, 12.0 V), (500 μA, 12.0 V), 1040, 202 kΩ, 20.6 kΩ, 147 MΩ, v_1

15.92 (a) (98.8 μA, 14.3 V), (300 μA, 14.3 V) (b) 551, 40.5 kΩ, (c) 49.0 kΩ (d) 34.6 MΩ, (e) v_2

15.97 (98.8 μA, 14.3 V), (300 μA, 14.3 V), 27800, 40.5 kΩ

15.102 (a) (250 μA, 15.6 V), (500 μA, 15.0 V) (b) 4300, , 165 kΩ (c) v_2 (d) v_1

15.107 (250 μA, 4.92 V), (6.10 μA, 4.30 V), (494 μA, 5.00 V), 4230, , 97.5 kΩ

15.109 (b-e) 12100, 101 kΩ, 180 kΩ, 66.3 MΩ, v_2

15.113 (250 μA, 10.9 V), (2.00 mA, 9.84 V), (5.00 mA, 12.0 V), 866, , 127 Ω

15.115 (300 μA, 5.10 V), (500 μA, 2.89 V), (2.00 mA, 5.00 V), 529, , 341 Ω

15.120 (99.0 μA, 5.00 V), (500 μA, 3.41 V), (2.00 mA, 5.00 V), 11400, 50.5 kΩ, 224 Ω

15.121 (4.95 μA, 2.36 V), (24.5 μA, 3.07 V), (245 μA, 3.00 V), 249, 1.01 MΩ, 1.63 kΩ, v_B, v_A, 900, $r_{\pi 3}$ and $r_{\pi 4}$ are low, R_{IN5} is low.

15.123 (99.0 μA, 1.40 V), (990 μA, 12.0 V), 189, 50.6 kΩ, 1.06 kΩ

15.127 (24.8 μA, 17.3 V), (24.8 μA, 17.3 V), (9.62 μA, 15.9 V), (490 μA, 16.6 V), (49.0 μA, 17.3 V), (4.95 mA, 18.0 V), 88.5 dB, 202 kΩ, 18.1 Ω

15.129 36.8 μA

15.131 196 μA

15.135 22.8 μA

15.137 5 mA, 0 mA, 10 mA, 12.5 percent

15.138 100 percent

15.141 70 mA, 19.6 V

15.144 6.98 mA, 0 mA

15.145 25.0 mΩ

15.147 (a) 22.8 μA, 43.9 MΩ

15.151 Two of many: 75 kΩ, 62 kΩ, 150 Ω; 68 kΩ, 12 kΩ, 1 kΩ

15.155 96.7 μA, 16.3 MΩ

15.158 20.2 μA, 101 MΩ

15.164 16.9 μA, 168 MΩ, 5.11 μA, 555 MΩ, 16.9 μA, 168 MΩ

15.166 44.1 μA, 22.1 MΩ, 10.0 μA, 210 MΩ

15.170 100 μA, 657 GΩ

15.171 (9.34 μA, 9.03 V), (4.62 μA, 7.62 V), 96.5 dB

15.173 □$_{o1}$□$_{f1}$/2

15.174 3.16 V

Chapter 16

16.1 4.06 kΩ ≤ R ≤ 4.31 kΩ

16.4 19.8 percent, 13.3 percent

16.6 7.69 percent, 0.813 μA, 0.855 μA

16.11 274 μA, 383 kΩ, 574 μA, 192 kΩ

16.16 (a) 944 μA, 68.9 kΩ, 1.52 mA, 41.5 kΩ

16.18 458 kΩ, 103 μA, 541 kΩ, 103 μA

16.20 185 μA, 299 μA

16.24 125 μA, 690 μA, 1.31 mA, 600 kΩ, 100 kΩ, 66.4 kΩ

16.27 10

16.31 15.7 μA, 5.10 MΩ

16.34 12.3 μA, 31.3 MΩ, 29.3 μA, 15.2 MΩ

16.38 172 kΩ, 9.78 kΩ, 0.445

16.42 $-V_{EE}$ + 1.16 V for $V_{CB3} \geq 0$

16.47 $-V_{EE}$ + 1.91 = -8.09 V

16.48 3.80/1

16.50 17.5 μA, 1.16 GΩ; 20.3 kV; 2.11 V

16.52 5%, 0

16.55 16.9 μA, 163 MΩ, 2750 V; $2V_{BE}$ = 1.4 V

16.57 3.80/1

16.59 127 μA, 1.89 MΩ, 129 μA, 1.97 MΩ

16.62 8.22 kΩ

16.65 318 μA, 295 μA, 66.5 μA

16.68 187 μA

16.72 46.5 μA, 140 μA

16.75 n > 1/3

16.77 26.4 μA

16.82 30.7 μA, 15.3 μA

16.85 462 μA, 308 μA

16.88 1.172 V, 307K

16.91 44.0 μV/K

16.94 2.293 kΩ, 10.47 kΩ

16.96 79.1, 6.28×10^{-5}, 122 dB

16.100 1200, 0, , 2.9 V

16.104 (100 μA, 8.70 V), (100 μA, 7.45 V), (100 μA, 2.50 V), (100 μA, 1.25 V), 323, 152

16.106 (125 μA, 1.54 V), (125 μA, 2.79 V), (125 μA, 2.50 V), (125 μA, 1.25 V); 19600

16.109 171 μA

16.110 (b) 100 μA

16.111 (125 μA, 8.63 V), (125 μA, 1.31 V), (125 μA, 10.0 V), (125 μA, 8.71 V), (125 μA, 1.29 V), (125 μA, 6.00 V), (125 μA, 2.75 V); 43.4; 14,900

16.113 10,800

16.118 6400; 80,000

16.119 7500; 7500

16.122 7.78, 574 Ω, 3.03×10^{5}, 60.0 kΩ

16.124 ±1.4 V, ±2.4 V

16.127 271 kΩ, 255 Ω

16.129 $V_{EE} \geq 2.8$ V, $V_{CC} \geq 1.4$ V; 3.8 V, 1.7 V

16.130 0.406 mS, 2.83 MΩ

16.134 (100 μA, 15.7 V), (50 μA, 12.9 V), (50 μA, 0.700 V), (50 μA, 1.40 V), (50 μA, 29.3 V), (100 μA, 0.700 V), (100 μA, 13.6 V), 1 mS, 752 kΩ

16.136 (25 μA, 2.50 V), (50 μA, 3.20 V)

16.137 (a) 125 μA, 75 μA, 62.5 μA, 37.5 μA (b) 125 μA, 0, 75 μA (c) 125 μA, 0, 75 μA

Chapter 17

17.1 $25, \dfrac{s^2}{(s+1)(s+20)}$, yes, $\dfrac{25s}{(s+20)}$, 3.18 Hz, 3.19 Hz

17.4 $200, \dfrac{1}{\left(1+\dfrac{s}{10^4}\right)\left(1+\dfrac{s}{10^5}\right)}$ yes, 1.59 kHz, 1.58 kHz

17.7 $200, \dfrac{s^2}{(s+1)(s+2)}, \dfrac{1}{\left(1+\dfrac{s}{500}\right)\left(1+\dfrac{s}{1000}\right)}$, , .356 Hz, 71.2 Hz; 0.380 Hz, 66.7 Hz

17.10 (b) −14.1 (23.0 dB), 11.8 Hz

17.12 19.3 dB, 151 Hz; 35.0 dB, 12.6 Hz

17.21 7.24 dB, 19.2 Hz

17.23 0.964, 0.627 Hz

17.24 0.152 μF

17.27 Cannot reach 1 Hz; f_L = 13.1 Hz for C_1 = , limited by C_3

17.29 0.351 μF

17.31 308 ps

17.34 −100; −107

17.36 0.977; 0.978

17.37 −5100, −98.0, −5000, −100; −350, −42.9, −300, −50

17.40 −98.7, 1.42 MHz

17.46 −129, 1.10 MHz

17.50 $1/10^5 RC$; $1/10^6 RC$; $1/sRC$

17.52 (2750 − j4.99) Ω, (2730 − j226) Ω, (836 − j1040) Ω

17.58 −9.44, 43.9 Hz, 9.02 MHz; 85.1 MHz

17.62 −1300; −92.3; −100, −1200

17.63 9.13, 40.9 MHz

17.66 2.30, 10.9 MHz

17.71 0.964, 114 MHz

17.73 $C_{GD} + C_{GS}/(1 + g_m R_L)$ for $\omega << \omega_T$

17.76 99.3 kHz

17.77 48.2 kHz

17.87 4 GHz, 39.8 ps

17.90 781 μA

17.91 8.33 MHz

17.95 10.6 MHz, 33.3 V/ms

17.100 8 V/μs

17.104 22.5 MHz, 2.91, −41.1

17.105 20.1 pF, 12.6, n = 2.81, 21.9 pF

17.107 15.2 MHz; 27.5 MHz

17.108 13.4 MHz, 7.98, $112\angle{-90°}$; 4.74 MHz, 5.21, $46.1\angle{-90°}$

17.113 10.9 MHz, 16.4, −75.1; 10.1 MHz, 3.96, −35.4

Chapter 18

18.5 $1/(1+A\beta)$; 9.99×10^{-3} percent

18.8 100 dB

18.13 800 MΩ; 2.00 Ω; 20.0 MΩ; 50 mΩ

18.15 18.8 kΩ, 1.02 mS, -75.0×10^3, 3141, 0.0993, 10.0; 0.0993 @ 0; 75,000 @ 0.0993

18.17 0.999, 43.9 MΩ, 2.49 Ω, 98.9 ms

18.20 $A\beta/(1 + A\beta)$; 99.9 percent

18.22 −33.0 kΩ; 8.11 kΩ; 0.705 Ω

18.23 82.2 Ω; 46.2 Ω; −32.4 kΩ; −32.4

18.24. 36.8 Ω; 18.6 Ω; −34.4 kΩ

18.26 0.973, 973 Ω

18.29 −446 kΩ, 50.4 kΩ, 2.45 kΩ

18.31 −11.0, 15.2 Ω, 2.72 MΩ

18.32 21.9 Ω; 12.3 Ω; −35.1

18.37 $\beta_o/(\beta_o + 1)$, $2/g_m$, $(\beta_o + 1)r_o$

18.40 58.2 dB

18.43 91.8

18.45 $(s/R_2C_2)/[s^2 + s(1/R_2C_2 + 1/(R_1\|R_2)C_1) + 1/R_1R_2C_1C_2]$

18.50 $T_V = 987$, $T_I = 110$, $T = 98.5$

18.59 114 dB, 0 Hz, 1000 Hz, 0 Hz, 101 kHz

18.62 46.1 kHz, 9.31 Hz, 81.0 kHz, 5.29 Hz

18.69 110 kHz; A ≥ 2000; larger

18.71 yes, but almost no phase margin; 1.83°

18.73 90.0°

18.75 12°; yes

18.81 phase margin is undefined; $|T(j\omega)| < 1$ for all ω

18.85 38.4°

18.86 $\omega = 1/RC$, $R_F = 2R$

18.88 63.7 kHz, 6.85 V

18.90 18.4 kHz, 10.7 V

18.95 9.00 MHz, 1.20

18.101 11.2 MHz, 18.1 MHz, 1.00

18.102 15.9155 mH, 15.9155 fF; 10.008 MHz, 10.003 MHz

18.103 9.190 MHz; 9.190 MHz