APPENDIX I

ANSWERS TO SELECTED PROBLEMS

CHAPTER 1

1.1 (a) 10 mA; (b) 10 kΩ; (c) 100 V; (d) 0.1 A   1.2 (a) 0.9 W, 1 W; (c) 0.09 W, 1/8 W; (f) 0.121 W, 1/8 W but preferably 1/4 W   1.4 17   1.7 2.94 V, 2.22 kΩ; 2.75 V to 3.14 V, 2.11 kΩ to 2.33 kΩ   1.9 10.2 V; shunt the 10-kΩ resistor a 157-kΩ resistor; add a series resistor of 200 Ω; shunt the 4.7-kΩ resistor with a 157 kΩ and the 10-kΩ resistor with 90 kΩ   1.11 250 Ω   1.13 Shunt R_L with a 1.1-kΩ resistor; current divider   1.15 0.77 V and 6.15 kΩ; 0.1 mA   1.17 1.88 μA; 5.64 V   1.19 (a) 10^{-7} s, 10^7 Hz, 6.28×10^7 Hz; (f) 10^3 rad/s, 1.59×10^2 Hz, 6.28×10^{-3} s   1.21 (a) $(1 - j1.59)$ kΩ; (c) $(71.72 - j45.04)$ kΩ   1.22 (b) 0.1 V, 10 μA, 10 kΩ   1.24 10 kΩ   1.28 (a) 165 V; (b) 24 V   1.30 0.5 V; 1 V; 0 V; 1 V; 1000 Hz; 10^{-3} s   1.32 4 kHz; 4 Hz   1.34 0, 101, 1000, 11001, 111001   1.36 (c) 11; 4.9 mV; 2.4 mV   1.38 7.056×10^5 bits per second   1.40 11 V/V or 20.8 dB; 22 A/A or 26.8 dB; 242 W/W or 23.8 dB; 120 mW; 95.8 mW; 20.2%   1.42 9 mV; 57.5 mV; 0.573 V   1.43 (a) 8.26 V/V or 18.3 dB; (b) 2.5 V/V or 8 dB; (c) 0.083 V/V or −21.6 dB   1.46 0.83 V; −1.6 dB; 79.2 dB; 38.8 dB   1.51 (a) 300 V/V; (b) 90 kΩ, 3×10^4 A/A, 9×10^6 W/W; (c) 667 Ω; (d) 555.7 V/V; (e) 100 kΩ, 100 Ω, 363 V/V   1.57 Transconductance amplifier; 100 kΩ; 100 kΩ; 121 V/V   1.65 $s/(s + 1/CR)$ 1.68 0.64 μF   1.71 $0.51/CR$ 1.72 13.3 pF; 0.26 pF   1.75 20 dB; 37 dB; 40 dB; 37 dB; 20 dB; 0 dB; −20 dB; 9900 Hz   1.76 $1/(sC_1R_1 + 1)$; 15.9 Hz; $-G_m s(R_2//R_3)/(s + 1/(C_2(R_2 + R_3)))$; 53 Hz; 16 Hz

CHAPTER 2

2.2 2002 V/V   2.5 20,000 V/V   2.8 (a) −10 V/V, 10 kΩ; (b) −10 V/V, 10 kΩ; (c) −10 V/V, 10 kΩ; (d) −10 V/V, 10 kΩ   2.11 (a) −1 V/V; (b) −10 V/V; (c) −0.1 V/V; (d) −100 V/V; (e) −10 V/V   2.12 (b) $R_1 = 10$ kΩ, $R_2 = 20$ kΩ (d) $R_1 = 10$ kΩ, $R_2 = 1$ MΩ   2.14 $R_{in} = 50.1$ kΩ   2.18 0 V, 5 V; −4.9 V to −5.1 V   2.20 (b) −66.4 V/V   2.21 ±5 mV   2.26 (b) 909 V/V   2.29 100 Ω; 100 Ω; 100 kΩ   2.31 (a) R, R, R, R; (b) $I, 2I, 4I, 8I$; (c) $-IR, -2IR, -4IR, -8IR$ 2.34 (a) 1.11 kΩ; (b) 0 Ω, ∞   2.36 $v_o = -(v_1 + ½ v_2)$; −1 V   2.43 12.8 kΩ   2.46 $R = 100$ kΩ; No   2.50 $v_0 = 4 \sin(2\pi \times 1000t)$ 2.53 (a) 0.099 V; 0.099 mA; 0.099 mA; (b) 10 V; 10 mA; 0 mA   2.54 $v_o/v_1 = 1/(1 + 1/A)$; 0.999, −0.1%; 0.990, −1.0%; 0.909, −9.1%   2.56 8.33 V/V; Shunt R_1 with $R_{sh} = 36$ kΩ; 9.09 V/V; 11.1 V/V   2.59 −10.714 to +10.714 V; 1.07 V   2.62 $v_o = v_2 - v_1$; R; $2R$; $2R$; R 2.64 $R_1 = R_3$ 2.66 68 dB   2.68 (a) 1, 0; (b) −5 V to +5 V; (c) 1, 0, −30 to +30 V   2.73 (a) −0.14 to +0.14 V; −14 to +14 V   2.76 $R_1 = 0.5$ kΩ fixed; $R_2 = 50$ kΩ   2.77 (a) 3 V/V, −3.0 V/V; (b) 6 V/V; (c) 56 V (peak-to-peak), 19.8 V (rms)   2.81 100 kHz; 1.59 μs   2.85 100 pulses   2.88 1.59 kHz; 10 V (peak-to-peak)   2.97 1.4 mV   2.99 57.5 mV; 42.5 to 57.5 mV; Add a 5-kΩ resistor in series with the positive input terminal; ±10 mV; add 5-kΩ resistor in series with the negative input load.   2.101 4.54 mV   2.104 (a) 0.1 V; (b) 0.2 V; (c) 10 kΩ, 10 mV; (d) 110 mV   2.108 46 dB; 501 Hz; 10 MHz   2.111 47.6 kHz; 19.9 V/V; 19.9 V/V

2.114 32 V/V   2.117 (a) $(\sqrt{2}-1)^{1/2}f_1$; (b) 10 kHz; (c) 64.4 kHz, about six times greater   2.120 For each, $f_{3dB}=f_i/3$ 2.127 (a) 31.8 kHz; (b) 0.795 V; (c) 0 to 200 kHz; (d) 1 V peak

CHAPTER 3

3.1 5.33×10^{-18}; 3.05×10^{-14}; 1.72×10^{-13}; 2.87×10^{-11}; 9.45×10^{-11} 3.4 1.5×10^{17} P atoms/cm^3 3.5 Hole concentration 2.25×10^4/cm^3; 2.23×10^9/cm^3 3.9 4.63×10^{17}/cm^3 3.10 0.432 A/cm^2 3.11 D_n: 35, 28.5, 18.1, 9.3; D_p: 12.4, 10.4, 6.7, 3.9   3.13 0.633 V; 0.951 μm; 0.8642 μm; 0.8642 μm; 5.53×10^{-14} C   3.22 3.6×10^{-15} A; 0.6645 V   3.27 259 pS; 1 pF

CHAPTER 4

4.1 (a) 0 A; 1.5 V; (b) 1.5 A; 0 V   4.2 (a) 5 V; 1 mA; (b) 5 V; 0 mA; (c) 5 V; 1 mA; (d) 5 V; 0 mA   4.8 50 kΩ   4.9 (a) 0 V; 0.3 mA; (b) 0.4 V; 0 mA   4.10 (a) 4.5 V; 0.225 mA; (b) 2 V; 0 A   4.15 29.67 V; 3.75 Ω; 0.75 A; 26.83 V; 30 V; 3 Ω; 20.5%; 136 mA; 1 A; 27 V   4.16 red lights; neither light; green lights   4.18 0.345 V; $1.45\times10^{12}I_S$ 4.20 537×10^{-18} A; 0.746 mA; 27.32 mA; 0.335 mA; 9.17 μA; 57.56 mV   4.23 7.9 mA; −10.15 mV   4.26 194 Ω   4.29 50°C; 9 W; 5.56°C/W   4.33 0.6635 V; 0.3365 mA   4.35 $R=947$ Ω   4.38 0.86 mA; 0 V; 0 A; 3.6 V   4.51 157 μA; −84.3° to −5.71°   4.58 −30 mV/mA; −120 mV/mA   4.60 8.96 V; 9.01 V; 9.46 V   4.63 8.83 V; 19.13 mA; 300 Ω; 9.14 V; ±0.01 V; +0.12 V; 578 Ω; 8.83 V; 90 mV/V; −27.3 mA/mA   4.68 16.27 V; 48.7%; 0.13; 5.06 V; 5.06 mA   4.69 16.27 V; 97.4%; 10.12 V; 10.12 mA   4.70 15.57 V; 94.8%; 9.44 V; 9.44 mA   4.72 55 V   4.75 (a) 166.7 μF; 15.4 V; 7.1%; 233 mA; 449 mA; (b) 1667 μF; 16.19 V; 2.25%; 735 mA; 1455 mA   4.76 (a) 83.3 μF; 15.5 V; 14.2%; 124.4 mA; 233 mA; (b) 833 μF; 16.19 V; 4.5%; 376 mA; 735 mA   4.79 (a) 23.6 V; (b) 444.4 μF; (c) 32.7 V; 49 V; (d) 0.73 A; (e) 1.36 A   4.91 14.14 V

CHAPTER 5

5.2 1.875 fC   5.7 2.38 μm   5.12 $W_p/W_n=2.5$ 5.13 238 Ω; 238 mV; 50   5.14 (a) 7.3 mA; (b) 1.62 mA; 1.61 mA; 17.7 mA   5.17 3.5 V; 1.5 V; 500 Ω; 100 Ω   5.18 1.0 V; 0.5 V; 1.5 V; 1.0 V   5.22 ≤0.3 V   5.23 100 Ω to 10 kΩ; (a) 200 Ω to 20 kΩ; (b) 50 Ω to 5 kΩ; (c) 100 Ω to 10 kΩ   5.31 500 kΩ; 50 kΩ; 2%; 2%   5.33 82.13 μA; 2.7%; use $L=6$ μm   5.38 0.24 mA; 0.52 mA; 0.54 mA; 0.59 mA   5.39 −3 V; +3 V; −4 V; +4 V; −1 V; −50 V; −0.02 V^{-1}; 1.39 mA/V^2 5.42 (b) −0.3%/°C   5.46 $R=11.1$ kΩ; $R=1.67$ kΩ   5.49 25 μm; 1.875 kΩ   5.50 2 μm; 5.6 μm; 2.8 kΩ   5.52 0.395 mA; 7.6 V   5.57 (a) 0.9 V; −1.6 V; (b) 4.1 V; 2.5 V; 0.9 V   5.59 (a) 7.5 μA; 1.5 V; (b) 4.6 μA; 1.4 V; (c) 1.5 V; 7.5 μA   5.61 (a) 1 V; 1 V; −1.32 V; (b) 0.2 V; 1.8 V; −1.35 V   5.65 0.4 V; 8.33   5.71 (a) 125 μA; 0.8 V; (b) 1 mS; (c) −8.0 V/V; (d) 80 kΩ; −7.3 V/V   5.75 4 μm; 1.0 V   5.77 −18.2 V/V; 1.207 V; −23.6 V/V   5.78 NMOS: 424 μS, 160 kΩ, 0.47 V; PMOS: 245 μS, 240 kΩ, 0.82 V   5.100 3.39 V; 0.86 mA to 0.36 mA; 1.1 kΩ   5.101 1 mA; 7.6%   5.102 2 V; 2.40 V; 2.55 mA   5.106 (a) −1.5 V; +0.5 V; 2 V; (b) −1.37 V; +0.5 V; +1.87 V   5.108 15.9 kΩ; 0.314 mA; 1.82 V   5.110 −11.2 V/V

CHAPTER 6

6.1 active; saturation; active; saturation; inversed active; active; cutoff; cutoff   6.8 53.3; 0.982   6.10 0.5; 0.667; 0.909; 0.952; 0.991, 0.995; 0.999; 0.9995   6.7 0.907 mA; 0.587 V

6.12 3 to 15 mA; 3.05 to 15.05 mA; 135 mW   6.17 −0.718 V; 4.06 V; 0.03 mA   6.22 −2 V; 0.82 mA; −0.57 V   6.24 0.91 mA; 9.09 mA; 0.803 V; 9.99 mA   6.28 (a) 1 mA; (b) −2 V; (c) 1 mA; 1 V; (d) 0.965 mA; 0.35 V   6.38 0.74 V; 0.54 V   6.40 3.35 μA 6.43 33.3 kΩ; 100 V; 3.3 kΩ   6.45 1.72 mA; 6 V; 34 V; 20 kΩ   6.47 150; 125; 1.474 mA 6.70 −360 V/V; 0.7 V, 2 mV   6.75 −100 V/V   6.78 3 mA; −120 V/V; −0.66 V; −0.6 V; 0.54 V; 0.6 V   6.51 (a) 1.3 V, 3.7 V; (b) 0.3 V, 4.7 V; (c) 0 V, +5 V   6.54 −0.7 V; +4.7 V; −0.5 V (−1 V; +5 V); +2.6 V (1.9 V, 2.6 V)   6.56 0.3 V; 15 μA; 0.8 mA; 0.785 mA; −1.075 V; 52.3; 0.98   6.61 (a) −0.7 V, 1.8 V; (b) 1.872 V, 1.955 mA; (c) −0.7 V, 0 V, 1.872 V; (d) 1.9 V, −0.209 V; (e) 1.224 V, 1.924 V, −0.246 V 6.64 1.08 kΩ; the transistor saturates.   6.94 1.25 V; 20 mA/V; 150 V/V   6.102 135; 41.8 Ω; 23 mA/V; 1.09 kΩ; −0.76 V/V   6.105 9.3 kΩ; 28.6 kΩ; 143 V/V 6.106 1 mA; 0.996 V/V; 0.63 V/V   6.152 (a) 1.73 mA, 68.5 mA/V, 14.5 Ω, 1.46 kΩ; (b) 148.2 kΩ, 0.93 V/V; (c) 18.21 kΩ, 0.64 V/V

CHAPTER 7

7.15 0.905 V; 1.4 V^2 7.19 (a) 0.5 mA; (b) 100 kΩ, 100 kΩ, 50 kΩ; (c) 2.5 kΩ, 20 mA/V; (d) 2.5 kΩ, 50 kΩ, −1000 V/V   7.46 10.5 kΩ; 0.25 V; 50 kΩ; 10 μA   7.49 100 μA; 0.2 V; 0.7 V; 5 μA   7.52 4: 25, 50, 200, 400 μA; 3: 16.7, 40, 133 μA; 1.05 V 7.54 (a) 10 μA to 10 mA; 0.633 to 0.806 V   7.57 0.2 mA; 10%   7.60 (a) 1.0 mA, −0.7 V, 3 V, 0.7 V, −5.7 V, −3.2 V; (b) 0.1 mA, −0.7 V, 3 V, 0.7 V, −0.7 V, −3.2 V 7.63 1.56 μA   7.64 8.93 MΩ; 0.95 V; 1.45 V; 100.4 μA   7.69 500 Ω   7.70 2 μA; 0.2% 7.76 (a) 5.7 kΩ; (b) 16.4 MΩ, 0.3 μA   7.78 7.46 MΩ   7.79 (a) 68.5 kΩ; (b) 112.5 MΩ   7.80 6.42 kΩ   7.84 12; 34   7.85 2.88   7.88 0.5 mA; 4 mA/V 7.93 16.7 GHz; 23.9 GHz; because the overlap capacitance is neglected.   7.94 15 V/V; 164.2 MHz; 2.5 GHz, 0.155 mA; quadrupled to 0.62 mA; 7.5 V/V; 656.8 MHz 7.97 5.3 MHz; 391 MHz

CHAPTER 8

8.9 0.724 V; 3.57 mA/V; 0.317 V; 1.6 mA   8.11 −1.5 V; +0.5 V; equal in both cases; 0.05 V; −0.05 V; 0.536 V   8.32 −1.665 V; 0.52 V   8.34 −1.53 V to 0.92 V 8.38 (a) $V_{CC} − (I/2)R_C$; (b) $−(I/2)R_C$, $+(I/2)R_C$; (c) 4 V; (d) 0.4 mA, 10 kΩ 8.41 (a) $20IR_C$ V/V; (b) $V_{CC} − 0.0275A_v$ 8.43 I_{E1} = 2 mA, I_{E2} = 1 mA, I_{C1} = 2 mA, I_{C2} = 1 mA; 17.3 mV   8.45 4 mA/V; 75.5 kΩ   8.48 (a) 0.2 mA, 10 mV; (b) 0.7 mA, 0.3 mA; (c) −2.4 V, +2.4 V; (d) 48 V/V   8.59 50 V/V; 50.5 kΩ   8.60 50 V/V; 50.5 kΩ   8.63 25 V/V; 40.4 kΩ; 0.001 V/V; 6.56 MΩ   8.64 (a) 200 V/V; (b) 20.2 kΩ; (c) 0.0005 V/V; (d) 112 dB; (e) 9.76 mΩ   8.67 1.8 mA; 360 V/V; 1.8 sin ωt V 8.68 R_E = 25 Ω; R_C = 10 kΩ; R_o ≤50 kΩ; R_{icm} = 5 MΩ; ±12 V would do, ±15 V would be better.   8.69 2%   8.70 0.008 V/V   8.77 −125 μV   8.79 1.7 mVM   8.81 (a) 0.3; (b) 0 8.115 $R_{id}{}^1$ = 40.4 kΩ; $R_{id}{}^2$ = 10.1 kΩ; 20.2 V/V; 3823 V/V decrease 8.116 R_5 = 7.34 kΩ; 4104 V/V; R_4 = 1.11 kΩ   8.117 (a) 173.1 × 10^3 V/V (b) 5583 V/V   8.118 (a) 0.97 mA; (b) 2.23 kΩ, 129 Ω; (c) 2.86 × 10^4 V/V

CHAPTER 9

9.1 1.43 V/V, 9.3 μF   9.4 −16 V/V; C_{C1} = 21.2 nF, C_S = 9.6 μF; C_{C2} = 0.5 μF; 50 Hz 9.17 6.3 GHz   9.19 5.4 GHz   9.24 500 MHz, 600 MHz, 251.9 ps, 0.435 pF 9.25 0.69 pF; 40 mA/V; 4 kΩ; 50 MHz   9.33 (a) −15.9 V/V; (b) 40.1 kHz 9.45 (a) 2.07; (b) 7.02   9.46 (a) 10^4 rad/s; (b) 10.1 Krad/s   9.47 5.67 × 10^6 rad/s

9.54 40.6 V/V; 243.75 ns; 3100 ns; 300 ns; 43.7 kHz   9.58 (a) -1000 V/V, $C_i = 1.001$ nF, $C_o = 1.001$ pF; (b) -10 V/V, $C_i = 110$ pF, $C_o = 11$ pF; (c) -1 V/V, $C_i = 20$ pF, $C_o = 20$ pF; (d) 1 V/V, $C_i = 0$ pF, $C_o = 0$ pF; (e) 10 V/V, $C_i = -90$ pF, $C_o = 9$ pF   9.62 6.37 GHz; 673.23 kHz; 21.39 MHz; 673.23 kHz   9.66 139 V/V; 21.22 GHz; 1.99 MHz; 83.22 MHz; 1.99 MHz   9.68 -80 V/V; 3.79 MHz; 303.2 MHz   9.72 159.1 fF   9.75 16 V/V; 398 MHz; 3.79 MHz; 3.79 MHz   9.88 0.964 V/V; 593.8 MHz   9.103 (a) 2.5 MΩ, -3943.6 V/V; (b) 107.8 kHz, $(C_L + C_{\mu 2})$ dominates, $C_{\mu 2}$ or C_T is the second most significant

CHAPTER 10

10.1 9.99×10^{-3}; 91.74; -8.26% 10.14 $A_{Mf} = A_M/(1 + A_M \beta)$; $W_{Lf} = W_L/(1 + A_M \beta)$ 10.16 1 MHz; 1 Hz   10.34 (a) $h^{11} = R_1 R_2/(R_1 + R_2)$ Ω, $h_{12} = R_2/(R_1 + R_2)$ V/V, $h_{21} = -R_2/(R_1 + R_2)$ A/A, $h_{22} = 1/(R_1 + R_2)$ Ω; (b) $h_{11} = 10$ Ω, $h_{12} = 0.01$ V/V, $h_{21} = -0.01$ A/V, $h_{22} = 0.99 \times 10^{-3}$ Ω 10.35 100 V/V; 1.001 MΩ 10.62 (a) shunt–series; (b) series–series; (c) shunt–shunt   10.80 10^4 rad/s; $\beta = 0.002$; 500 V/V   10.82 $K < 0.008$ 10.84 9.9 V/V; 1.01 MHz; 10 MHz; 101   10.85 (a) 5.5×10^5 Hz, $\beta = 2.025 \times 10^{-3}$; (b) 330.6 V/V; (c) 166.3 V/V, $1/2$; (d) 1.33   10.87 $\omega_0 = 1/CR$; $Q = 1/(2.1 - K)$; 0.1; 0.686; $K = 2.1$ 10.89 1 MHz; 90°   10.91 56.87°; 54.07°; 59.24°; 52.93°   10.93 159.2 μs; 39.3°; 20 dB   10.95 3 KHz   10.96 15 KHz; 200   10.97 $1/10CR$; $1/CR$; $1/(100 \times C_f \times R)$; $9.1/CR$ 10.98 100 Hz; 1.59 nF   10.99 58.8 pF; 37.95 MHz

CHAPTER 11

11.1 Upper limit (same in all cases): 4.7 V, 5.4 V; lower limits: -4.3 V, -3.6 V; -2.15 V, -1.45 V   11.4 152 Ω; 0.998 V/V; 0.996 V/V; 0.978 V/V; 2%   11.6 $V_{CC}I$ 11.8 5 V   11.10 4.5 V; 6.4%; 625 Ω 11.12 5.0 V peak; 3.18 V peak; 3.425 Ω; 4.83 Ω; 3.65 W; 0.647 W   11.19 12.5   11.21 20.7 mA; 788 mW; 7.9°C; 37.6 mA   11.22 1.34 kΩ; 1.04 kΩ 11.30 50 W; 2.5 A   11.32 140°C; 0.57 V   11.34 100 W; 0.4°C/W   11.45 13 Ω; 433 mV; 0.33 μA   11.47 $R_1 = 60$ kΩ; $R_2 = 5$ kΩ; 0.01 μA   11.49 $I_{E1} = I_{E2} \approx 17$ μA; $I_{E3} = I_{E4} \approx 358$ μA; $I_{E5} \approx I_{E6} = 341$ μA; 10.5 V   11.50 14 V; 1.9 W; 11 V   11.51 $R_3 = R_4 = 40$ Ω; $R_1 = R_2 = 2.2$ kΩ 11.53 40 kΩ; 50 kΩ 11.55 $L = \mu_n(v_{GS} - V_t)/U_{\text{sat}}$; 3 μm; 3 A; 1 A/V

CHAPTER 12

12.24 36.3 μA   12.25 0.625 V; for A, 7.3 mA/V, 134.3 Ω, 6.85 kΩ, 274 kΩ; for B, 21.9 mA/V, 44.7 Ω, 2.28 kΩ, 91.3 kΩ 12.29 593 mV; 518 mV; 7.5 kΩ 12.31 4.75 μA; 1.94 kΩ 12.33 56.5 kΩ; 9.353 μA   12.36 5.6 mV   12.38 6.37 kΩ; 270 μA   12.40 1.68 mA; 50.4 mW   12.42 Raise R'_1, R'_2 to 4.63 kΩ 12.45 1.4 mV   12.50 3.1 MΩ; 9.38 mA/V   12.52 4.2 V to -3.6 V   12.54 105.6 dB; $|V_o| < 4$ V; 21.0 mA   12.56 108 dB; 61.9 Ω 12.58 7.6 MHz   12.60 318 kΩ 12.62 159.2 kHz; 15.9 MHz

CHAPTER 13

13.6 1.5 V; 1.5 V; 1.5 V; 0 V; 3 V; 1.5 V; 1.5 V; ∞ 13.8 0.349 to 0.451 V; 0.749 to 0.852 V; 0 V; 1.2 V; 0.349 to 0.452 V; 0.348 to 0.451 V   13.19 4.36 mW; 1.48 mW   13.21 (a) $t_{PLH} = 1.6$ ns, $t_{PHL} = 0.8$ ns; (b) $C = 1.43$ pF; (c) $C_o = 0.86$ pF, $C_i = 0.57$ pF   13.25 (a) 0.66, 0.435 (b) 0.436, 0.435   13.29 9.09 mV; 50 mV   13.46 24   13.53 $p_A = p : p_B = p_C = p_D = 2p$; and $n_A = n_B = 2n : n_C = n_D = 2(2n) = 4n$ 13.55 t_{PHL} is 4 times larger; t_{PLH} is the same

CHAPTER 14

14.1 (a) 0.693 $R_D C$; (b) 0.5$R_D C$, for a 21.5% reduction 14.2 1.52; 0.97 V; 1.69 V; 1.2 V; 2.5 V; 0.28 V; 0.81 V; 0.69 V 14.4 $r \approx 2.1$; NM_{Lmax} 0.731 V 14.6 1.33 14.23 9.38 ns 14.30 3 ms; 333 Hz 14.33 2.27 GHz 14.35 33.3 MHz; high 13 ns; low 17 ns 14.38 0.33 V/V; 8.95 V/V; 0.37 V/V 14.39 (a) −1.375 V, −1.265 V; (b) −1.493 V, −1.147 V 14.41 21.2 14.43 7 cm 14.45 $(W/ \ L) = 5 \ \mu m / 1 \ \mu m$; 6.5 μA 14.46 2.32 V; 3.88 mA 14.47 For R_1: 50%; 36.5 kΩ; 20%; 91.1 kΩ; for R_2: 50%; 6.70 kΩ; 20%; 16.7 kΩ; 50%; $R_1 / R_2 = 5.45$; 20%; $R_1 / R_2 = 5.45$ 14.48 83.2 ps; 50.7 ps; 67.0 ps 14.50 $(W/L)_{NA} = (W/L)_{NB} = 2(W/L)_N$; $(W/L)_{PA} = (W/L)_{PB} = (W/L)_P$

CHAPTER 15

15.10 2.236 V; 100 V/V 15.12 1024; 1024; 400 pF; 225 pF; 220 fF/bit; 2.8 times 15.13 60% 15.29 41 mV 15.31 0.4 pA 15.32 1.589 mA/V; 11.36 μm; 34.1 μm; 1.56 ns 15.33 680 μA/V; 0.482 V; 0.206 V; 50%; 7.5 ns 15.38 9; 512; 18; 4608 NMOS and 512 PMOS transistors 15.39 9; 1024; 4608; 512; 5641; 521 15.44 0100, 0000, 1000, 1001, 0101, 0001, 0110, and 0010 15.46 2.42 ns; 23 ns, 3.16 V; 1.90 ns

CHAPTER 16

16.1 1 V/V, 0°, 0 dB, 0 dB; 0.894 V/V, −26.6°, −0.97 dB, 0.97 dB; 0.707 V/V, −45.0°, −3.01 dB, 3.01 dB; 0.447 V/V, −63.4°, −6.99 dB, 6.99 dB; 0.196 V/V, −78.7°, −14.1 dB, 14.1 dB; 0.100 V/V, −84.3°, −20.0 dB, 20.0 dB; 0.010 V/V, −89.4°, −40.0 dB, 40.0 dB 16.5 0.5088 rad/s; 3 rad/s; 5.9 16.9 $T(s) = 0.2225 (s^2 + 4)/[(s + 1)(s^2 + s + 0.89)]$ 16.11 $T(s) = 0.5/s^3 + 2s^2 + 2s + 1$; poles at $s = −1, −1/2 \pm j\sqrt{3}/2$, 3 zeros at $s = \infty$ 16.13 28.6 dB 16.19 $R_1 = 10$ kΩ; $R_2 = 100$ kΩ; $C = 159$ pF 16.21 40 dB 16.23 $T(s) = −(S − \omega_0/ \ S + \omega_0)$; 2.68 kΩ, 5.77 kΩ, 10 kΩ, 17.3 kΩ, 37.3 kΩ 16.25 $T(s) = 10^6/(s^2 + 10^3 s + 10^6)$; 0.707 rad/s; 1.15 V/V; 1.21 dB 16.33 $L = 500$ mH; $C = 20$ nF 16.35 $s^2/(s^2 + s/RC + 1/LC)$ 16.39 $L_1/L_2 = 0.2346$; $|T| = L_2/(L_1 + L_2)$; $|T| = 1$ 16.43 $R_1 = R_2 = R_3 = R_5 = 3.979$ kΩ; $R_6 = 39.79$ kΩ; $C_{61} = 6.4$ nF; $C_{62} = 3.6$ nF 16.44 $C_4 = C_6 = 1$ nF; $R_1 = R_2 = R_3 = R_5 = R_6 = 159.16$ kΩ 16.49 $C = 10$ nF; $R = 15.92$ kΩ; $R_1 = R_f = 10$ kΩ; $R_2 = 10$ kΩ; $R_3 = 390$ kΩ; 39 V/V 16.51 ±1% 16.55 $R_3 = 141.4$ kΩ; $R_4 = 70.7$ kΩ 16.57 $4/RC$; 2; 8 V/V 16.59 High-pass; 1 V/V; $R_3 = 141.4$ kΩ; $R_4 = 70.7$ kΩ 16.64 0; $2Q^2/A$

CHAPTER 17

17.1 (a) $\omega = \omega_0$, $AK = 1$; (b) $−2Q/\omega_0$; (c) $\Delta\omega_0/\omega_0 = −\Delta\phi/2Q$ 17.5 20 dB; ±180° 17.9 $1/RC$; ¾; ¾ 17.10 $1.15/RC$ 17.15 20.3 V 17.17 1; 29R; 0.065/RC 17.23 2.01612 MHz to 2.0172 MHz 17.25 (a) $V_{TL} = V_R (1 − R_1/R_2) − L_+R_1/R_2$, $V_{TH} = V_R(1 + R_2/R_1) − L_-R_1/R_2 L_-$; (b) $R_2 = 200$ kΩ, $V_R = 47.62$ mV 17.28 (a) +12 V or −12 V 17.29 $V_Z = 6.8$ V; $R_1 = R_2 = 37.5$ kΩ; $R = 4.1$ kΩ 17.33 $V_Z = 6.8$ V; $R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 200$ kΩ; $R_7 = 5.1$ kΩ; triangle with period of 100 μs and ±7.5 V peaks 17.35 96 μs 17.38 (a) 9.1 kΩ; (b) 13.3 V 17.39 $R_A = 21.2$ kΩ; $R_B = 10.7$ kΩ 17.41 $V = 1.0996$ V; $R = 400$ Ω; Table rows, for v_O, θ, 0.7 sin θ, error % are: 0.70 V, 90°, 0.700 V, 0%; 0.65 V, 63.6°, 0.627 V, 3.7%; 0.60 V, 52.4°, 0.554 V, 8.2%; 0.55 V, 46.1°, 0.504 V, 9.1%; 0.50 V, 41.3°, 0.462 V, 8.3%; 0.40 V, 32.8°, 0.379 V, 5.6%; 0.30 V, 24.6°, 0.291 V, 3.1%; 0.20 V, 16.4°, 0.197 V, 1.5%; 0.10 V, 8.2°, 0.100 V, 0%; 0.00 V, 0°, 0.0 V, 0%. 17.42 2.5 V 17.55 10 mV, 20 mV, 100 mV; 50 pulses, 100 pulses, 200 pulses