Microelectronic Circuit Design Third Edition - Part III Solutions to Exercises - Partial

---

CHAPTER 10

Page 509

$V_o = \sqrt{2P_oR_L} = \sqrt{2(20W)(16\Omega)} = 25.3\ V \quad A_v = \frac{V_o}{V_i} = \frac{25.3V}{0.005V} = 5.06x10^3$

$I_o = \frac{V_o}{R_L} = \frac{25.3V}{16\Omega} = 1.58\ A \quad I_i = \frac{V_i}{R_S + R_{in}} = \frac{0.005V}{10k\Omega + 20k\Omega} = 0.167\mu A \quad A_i = \frac{I_o}{I_i} = \frac{1.58A}{0.167\mu A} = 9.48x10^6$

$A_P = \frac{P_o}{P_S} = \frac{25.3V(1.58A)}{0.005V(0.167\mu A)} = 4.79x10^{10} \quad \text{Checking}: A_p = (5.06x10^3)(9.48x10^6) = 4.80x10^{10}$

Page 510

$(i)\ A_{vdB} = 20\log(5060) = 74.1\ dB \quad A_{idB} = 20\log(9.48x10^6) = 140\ dB \quad A_{PdB} = 10\log(4.80x10^{10}) = 107\ dB$

$(ii)\ A_{vdB} = 20\log(4x10^4) = 92.0\ dB \quad A_{idB} = 20\log(2.75x10^8) = 169\ dB \quad A_{PdB} = 10\log(1.10x10^{13}) = 130\ dB$

Page 511

(i) The constant slope region spanning a maximum input range is between $0.4 \le v_I \le 0.65$,

and the bias voltage V_I should be centered in this range: $V_I = \frac{0.4 + 0.65}{2}V = 0.525\ V$.

$v_i \le 0.65 - 0.525 = 0.125\ V$ and $v_i \le 0.525 - 0.40 = 0.125\ V$. For $v_I = 0.8V$, the slope is 0. $A_v = 0$.

$(ii)\ v_O = V_O + v_o$ For $v_i = 0,\ v_I = V_I = 0.6,\ V_O = 14V$ and $A_v = +40.\ V_o = A_vV_i = 40(0.01V) = 4V$

$v_O = (14.0 + 4.00\sin 1000\pi t)$ volts $\quad V_O = 14\ V$

Page 519

$$g_{11} = \frac{1}{20k\Omega + 76(50k\Omega)} = 0.262\ \mu S \quad g_{21} = 0.262\mu S(76)(50k\Omega) = 0.995$$

$$g_{22} = \frac{1}{50k\Omega} + \frac{1}{20k\Omega} + \frac{75}{20k\Omega} = 3.82\ mS \quad g_{12} = -\frac{1}{g_{22}(20k\Omega)} = -\frac{1}{3.82mS(20k\Omega)} = \text{-}0.0131$$

$$R_{in} = \frac{1}{g_{11}} = 3.82\ M\Omega \quad A = g_{21} = 0.995 \quad R_{out} = \frac{1}{g_{22}} = 262\ \Omega$$

Page 520

$$(i)\ P = A_v A_i = A_v^2 \frac{R_S + R_{in}}{R_L}$$

$$(ii)\ V_o = \sqrt{2(100W)(8\Omega)} = 40\ V \qquad 40 = 0.001\left(\frac{50k\Omega}{5k\Omega + 50k\Omega}\right)A\left(\frac{8\Omega}{0.5\Omega + 8\Omega}\right) \rightarrow A = 46,800$$

$$P = \frac{I_o^2 R_L}{2} = \frac{0.5\Omega}{2}\left(\frac{40V}{8\Omega}\right)^2 = 6.25\ W \qquad A_i = \left(\frac{40V}{8\Omega}\right)\left(\frac{5k\Omega + 50k\Omega}{0.001V}\right) = 2.75\ x\ 10^8$$

$$(iii)\ 40 = 0.001\left(\frac{5k\Omega}{5k\Omega + 5k\Omega}\right)A\left(\frac{8\Omega}{8\Omega + 8\Omega}\right) \rightarrow A = 160,000$$

$$P = \frac{I_o^2 R_L}{2} = \frac{8\Omega}{2}\left(\frac{40V}{8\Omega}\right)^2 = 100\ W! \qquad A_i = \left(\frac{40V}{8\Omega}\right)\left(\frac{5k\Omega + 5k\Omega}{0.001V}\right) = 5.00\ x\ 10^7$$

Page 521

$$A_v(s) = \frac{300s}{(s + 5000)(s + 100)}$$

Zeros at s = 0 and s = ∞; Poles at s = -5000 and s = −100.

Page 523

$$A_v(s) = -\frac{2\pi\, x\, 10^6}{s + 5000\pi} = \frac{-400}{1 + \dfrac{s}{5000\pi}} \rightarrow A_{mid} = -400 \qquad f_H = \frac{5000\pi}{2\pi} = 2.50\ kHz$$

$$BW = f_H - f_L = 2.50\ kHz - 0 = 2.50\ kHz \qquad GBW = (400)(2.50kHz) = 1.00\ MHz$$

Page 524

$$(i)\ \left|A_v(j5)\right| = 50\frac{\left|5^2 - 4\right|}{\sqrt{\left(5^2 - 2\right)^2 + 4\left(5^2\right)}} = 41.87 \quad 20\log(41.87) = 32.4\ dB$$

$$\angle A_v(j5) = \angle\left(5^2 - 4\right) - \tan^{-1}\left[\frac{-2(5)}{5^2 - 2}\right] = 0 - \left(-23.5^o\right) = 23.5^o$$

$$\left|A_v(j1)\right| = 50\frac{\left|1^2 - 4\right|}{\sqrt{\left(1^2 - 2\right)^2 + 4\left(1^2\right)}} = 67.08 \quad 20\log(41.87) = 36.5\ dB$$

$$\angle A_v(j1) = \angle\left(1^2 - 4\right) - \tan^{-1}\left[\frac{-2(1)}{1^2 - 2}\right] = 180^o - \left(-63.43^o\right) = 243^o = -117^o$$

Page 524

$$(ii)\ \mathrm{A_v}(j\omega) = \frac{20}{1 + j\dfrac{0.1\omega}{1-\omega^2}}$$

$$\left|A_v(j0.95)\right| = \frac{20}{\sqrt{1^2 + \dfrac{(0.1)^2(0.95^2)}{(1-0.95^2)^2}}} = 14.3 \qquad \angle A_v(j0.95) = \angle 20 - \tan^{-1}\left[\frac{0.1(0.95)}{1-0.95^2}\right] = 0 - (44.3^o) = -44.3^o$$

$$\left|A_v(j1)\right| = \frac{20}{\sqrt{1^2 + \dfrac{(0.1)^2(1^2)}{(1-1^2)^2}}} = 0 \qquad \angle A_v(j1) = \angle 20 - \tan^{-1}\left[\frac{0.1(1)}{1-1^2}\right] = 0 - (90^o) = -90.0^o$$

$$\left|A_v(j1.1)\right| = \frac{20}{\sqrt{1^2 + \dfrac{(0.1)^2(1.1^2)}{(1-1.1^2)^2}}} = 17.7 \qquad \angle A_v(j1.1) = \angle 20 - \tan^{-1}\left[\frac{0.1(1.1)}{1-1.1^2}\right] = 0 - (-27.6^o) = 27.6^o$$

Page 526

$$f_H = \frac{1}{2\pi}\frac{1}{(1k\Omega \| 100k\Omega)(200\,pF)} = 804\ kHz$$

Page 527

$$A_v(s) = \frac{250}{1 + \dfrac{250\pi}{s}} \qquad A_o = 250 \qquad f_L = \frac{250\pi}{2\pi} = 125\ Hz \qquad f_H = \infty \qquad BW = \infty - 125 = \infty$$

Page 528

$$f_L = \frac{1}{2\pi}\frac{1}{(1k\Omega \| 100k\Omega)(0.1\mu F)} = 15.8\ Hz$$

Page 529

$$(i)\ A_v(s)=\frac{-400}{\left(1+\frac{100}{s}\right)\left(1+\frac{s}{50000}\right)} \qquad A_o=400 \text{ or } 52\ dB$$

$$f_L=\frac{100}{2\pi}=15.9\ Hz \quad f_H=\frac{50000}{2\pi}=7.96\ kHz \quad BW=7960-15.9=7.94\ kHz$$

$$(ii)\ \angle A_v(j0)=-90-0-0=-90^o$$

$$\angle A_v(j100)=-90^o-\tan^{-1}\left(\frac{100}{100}\right)-\tan^{-1}\left(\frac{100}{50000}\right)=-90-45-0.57=-136^o$$

$$\angle A_v(j50000)=-90^o-\tan^{-1}\left(\frac{50000}{100}\right)-\tan^{-1}\left(\frac{50000}{50000}\right)=-90-89.9-45=-225^o$$

$$\angle A_v(j\infty)=-90-90-90=-270^o$$

Page 531

The numerator coefficient should be 6 x10^6.

$$A_v(s)=30\frac{2x10^5 s}{s^2+2x10^5 s+10^{14}} \qquad A_o=30$$

$$f_o=\frac{1}{2\pi}\sqrt{10^{14}}=1.59\ MHz \quad Q=\frac{10^7}{2x10^5}=50 \quad BW=\frac{1.59\,MHz}{50}=31.8\ kHz$$

Page 533

The transfer fucntion should be $A_v(s)=\dfrac{6.4x10^{12}\pi^2 s}{(s+200\pi)(s+80000\pi)^2}$.

$$A_v(s)=\frac{1000}{\left(1+\frac{200\pi}{s}\right)\left(1+\frac{s}{80000\pi}\right)^2} \qquad A_o=1000 \text{ or } 60\ dB$$

$$f_L=\frac{200\pi}{2\pi}=100\ Hz \qquad f_H=0.644\left(\frac{80000\pi}{2\pi}\right)=25.8\ kHz \quad BW=25800-100=25.7\ kHz$$
