Homework 10 Solutions

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Solution 7.31

From Problem 7.30 $R_{TH} = 0.6\text{ K},\ I_{CQ} = 31.9\text{ mA},\ r_\pi = 81.5\ \Omega$

$\tau_{C2} >> \tau_{C1}$ and $f = \dfrac{1}{2\pi\tau}$ so $f_{3-dB}(C_{C2}) << f_{3-dB}(C_{C1})$

Then $f_{3-dB}(C_{C2}) \Rightarrow C_{C1}$ acts as an open circuit and for $f_{3-dB}(C_{C1}) \Rightarrow C_{C2}$ acts as a short circuit.

$$f_{3-dB}(C_{C1}) = 20\text{ Hz} = \frac{1}{2\pi\tau_{C1}} \Rightarrow \tau_{C1} = 0.007958\text{ s}$$

$$R_{ib} = r_\pi + (1+\beta)(R_E \| R_L) = 81.5 + (101)(50\|10) = 923.2\ \Omega$$

$$\tau_{C1} \Rightarrow R_{eq1} = R_S + R_{TH} \| R_{ib} = 300 + 600\|923.2 = 663.7\ \Omega$$

$$C_{C1} = \frac{0.007958}{663.7} \Rightarrow C_{C1} = 12\ \mu\text{F}$$

$$\tau_{C2} = 100\tau_{C1} = 0.7958\text{ s}$$

$$R_{eq2} = R_L + R_E \left\| \left(\frac{r_\pi + R_{TH}}{1+\beta}\right) = 10 + 50 \right\| \left(\frac{81.5+600}{101}\right)$$

$$R_{eq2} = 10 + 50\|6.748 = 15.95\ \Omega$$

$$C_{C2} = \frac{0.7958}{15.95} \Rightarrow \underline{C_{C2} = 0.050\text{ F}}$$

Solution 7.41

(a) $A_\upsilon = -g_m\left(R_D \| R_L \| \frac{1}{sC_L}\right) = -g_m\left[\frac{(R_D \| R_L)\cdot\frac{1}{sC_L}}{(R_D \| R_L) + \frac{1}{sC_L}}\right]$

$$A_\upsilon = -g_m(R_D \| R_L)\left[\frac{1}{1 + s(R_D \| R_L)C_L}\right]$$

(b) $\tau = (R_D \| R_L)C_L$

(c) $5 = I_D R_S + V_{SG} = K_p R_S(V_{SG} + V_{TP})^2 + V_{SG}$

$$5 = (0.25)(3.2)(V_{SG} - 2)^2 + V_{SG}$$

We find $0.8V_{SG}^2 - 2.2V_{SG} - 1.8 = 0 \Rightarrow V_{SG} = 3.41$ V

$$I_{DQ} = (0.25)(3.41 - 2)^2 = 0.497 \text{ mA}$$

$$\tau = (10 \| 20) \times 10^3 \times 10 \times 10^{-12} = 6.67 \times 10^{-8} \text{ s}$$

$$f_H = \frac{1}{2\pi\tau} = \frac{1}{2\pi(6.67 \times 10^{-8})} \Rightarrow f_H = 2.39 \text{ MHz}$$

$$g_m = 2\sqrt{K_p I_{DQ}} = 2\sqrt{(0.25)(0.497)} = 0.705 \text{ mA/V}$$

$$A_\upsilon = -g_m(R_D \| R_L) = -(0.705)(10 \| 20) = -4.7$$

Solution 7.49

(a)

$$f = 10 \text{ kHz} = 10^4$$

$$Z_i = 200 + \frac{2500\left(1 - j\left(10^4\right)\left(1.333\times10^{-6}\right)\right)}{1+\left(10^4\right)^2\left(1.333\times10^{-6}\right)^2}$$

$$= 200 + 2500 - j33.3 = 2700 - j33.3$$

(b)

$$f = 100 \text{ kHz} = 10^5$$

$$Z_i = 200 + \frac{2500\left(1 - j\left(10^5\right)\left(1.333\times10^{-6}\right)\right)}{1+\left(10^5\right)^2\left(1.333\times10^{-6}\right)^2}$$

$$Z_i = 200 + 2456 - j327 = 2656 - j327$$

(c)

$$f = 1 \text{ MHz} = 10^6$$

$$Z_i = 200 + \frac{2500\left(1 - j\left(10^6\right)\left(1.333\times10^{-6}\right)\right)}{1+\left(10^6\right)^2\left(1.333\times10^{-6}\right)^2}$$

$$Z_i = 200 + 900 - j1200 = 1100 - j1200$$

(d)

Solution 7.59

(a) $C_M = C_{gd}\left[1+g_m\left(r_o \| R_D\right)\right] = (12)\left[1+(3)(120\|10)\right] = 344.3$ fF

(b) $f_{3-dB} = \dfrac{1}{2\pi\tau}$

$$\tau = r_i\left(C_{gs} + C_M\right) = \left(10^4\right)(80+344.3)\times 10^{-15} = 4.243\times 10^{-9}\ \text{s}$$

$$f_{3-dB} = \frac{1}{2\pi\left(4.243\times 10^{-9}\right)} \Rightarrow f_{3-dB} = 37.5\ \text{MHz}$$

Solution 7.63

(b) $V_{GS} = \left(\dfrac{225}{225+500}\right)(10) = 3.103$ V

$I_{DQ} = (1)(3.103-2)^2 = 1.218$ mA

$g_m = 2\sqrt{K_n I_{DQ}} = 2\sqrt{(1)(1.218)} = 2.207$ mA/V

$C_M = C_{gd}(1+g_m R_D) = (8)[1+(2.207)(5)] = 96.28$ fF

(a) $f_{3-dB} = \dfrac{1}{2\pi\tau}$, $\tau = (R_i \| R_1 \| R_2)(C_{gs} + C_M)$

Now $R_i \| R_1 \| R_2 = 1 \| 500 \| 225 = 0.9936\,\text{k}\Omega$

$\tau = (0.9936\times 10^3)(50+96.28)\times 10^{-15} = 1.453\times 10^{-10}$ s

$f_{3-dB} = \dfrac{1}{2\pi(1.453\times 10^{-10})} \Rightarrow f_{3-dB} = 1.095$ GHz

$A_\upsilon = -g_m R_D\left(\dfrac{R_1 \| R_2}{R_1 \| R_2 + R_i}\right) = -(2.207)(5)\left(\dfrac{155.2}{155.2+1}\right) = -10.96$