

## 第二章 选频网络

注意：①有部分答案有差异；

②3-1 题是 2-1 题；

③只有计算题答案和部分问答题；

④答案不齐全。

$$3-1 \quad \therefore f_0 = 1\text{MHz}$$

$$2\Delta f_{0.7} = 1 \times 10^6 - 990 \times 10^3 = 10(\text{kHz})$$

$$Q = \frac{f_0}{2\Delta f_{0.7}} = \frac{1 \times 10^6}{10 \times 10^3} = 100$$

$$R = 10\Omega$$

$$L = \frac{QR}{\omega_0} = \frac{100 \times 10}{2 \times 3.14 \times 10^6} = 159(\mu\text{H})$$

$$C = \frac{1}{\omega_0^2 L} = \frac{1}{(2 \times 3.14 \times 10^6)^2 \times 159 \times 10^{-6}} = 159(\text{pF})$$

$$3-2 \quad \therefore (1) \quad \omega_{01} = \frac{1}{\sqrt{L_1 C_1}} \quad \omega_{02} = \frac{1}{\sqrt{L_2 C_2}} \quad , \quad .$$

$$(2) \quad \omega_{01} = \frac{1}{\sqrt{L_1 C_1}} \quad \omega_{02} = \frac{1}{\sqrt{L_2 C_2}} \quad , \quad .$$

$$(3) \quad \omega_{01} = \frac{1}{\sqrt{L_1 C_1}} \quad \omega_{02} = \frac{1}{\sqrt{L_2 C_2}} \quad , \quad .$$

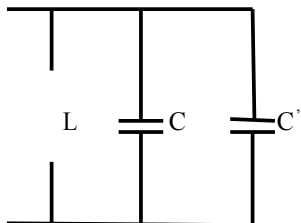
$$3-3 \quad \therefore Z = \frac{(R + j\omega_0 L)(R + \frac{1}{j\omega_0 C})}{R + j\omega_0 L + R + \frac{1}{j\omega_0 C}} = \frac{R^2 + \frac{L}{C} + j\omega_0 LR(1 - \frac{1}{\omega_0^2 LC})}{2R + j\omega_0 L(1 - \frac{1}{\omega_0^2 LC})} = \frac{R^2 + \frac{L}{C}}{2R} = R$$

$$3-4 \quad \therefore (1) \quad (15 + C) \times 1605^2 = (450 + C) 535^2 \quad C = 40 \text{pF}$$

$$(12 + C) \times 1605^2 = (100 + C) 535^2 \quad C = -1 \text{pF} ( \quad )$$

$$2) L = \frac{1}{\omega_0^2 (C + C')} = \frac{1}{(2 \times 3.14 \times 535 \times 10^3)^2 \times (450 + 40) \times 10^{-12}} = 180(\mu\text{H})$$

3)



$$3-5 \quad \therefore Q_0 = \frac{1}{\omega_0 C_0 R} = \frac{1}{2 \times 3.14 \times 1.5 \times 10^6 \times 100 \times 10^{-12} \times 5} = 212$$

$$L_0 = \frac{1}{\omega_0^2 C_0} = \frac{1}{(2 \times 3.14 \times 1.5 \times 10^6)^2 \times 100 \times 10^{-12}} = 112(\mu H)$$

$$I_{om} = \frac{V_{om}}{R} = \frac{1 \times 10^{-3}}{5} = 0.2(mA)$$

$$V_{Lom} = V_{Com} = Q_0 V_{Sm} = 212 \times 1 \times 10^{-3} = 212(mV)$$

$$3-6 \quad \therefore L = \frac{1}{\omega_0^2 C} = \frac{1}{(2 \times 3.14 \times 10^6)^2 \times 100 \times 10^{-12}} = 253(\mu H)$$

$$Q_0 = \frac{V_C}{V_S} = \frac{10}{0.1} = 100$$

$$\frac{C \cdot C_X}{C + C_X} = \frac{1}{\omega_0^2 L} = \frac{1}{(2 \times 3.14 \times 10^6)^2 \times 253 \times 10^{-6}} = 100(pF) \rightarrow C_X = 200 pF$$

$$R_X = \frac{\omega_0 L}{Q} - \frac{\omega_0 L}{Q_0} = \frac{2 \times 3.14 \times 10^6 \times 253 \times 10^{-6}}{2.5/0.1} - \frac{2 \times 3.14 \times 10^6 \times 253 \times 10^{-6}}{100} = 47.7(\Omega)$$

$$Z_X = R_X - j \frac{1}{\omega_0 C_X} = 47.7 - j \frac{1}{2 \times 3.14 \times 10^6 \times 200 \times 10^{-12}} = 47.7 - j796(\Omega)$$

$$3-7 \quad \therefore L = \frac{1}{\omega_0^2 C} = \frac{1}{(2 \times 3.14 \times 5 \times 10^6) \times 50 \times 10^{-12}} = 20.2(\mu H)$$

$$Q_0 = \frac{f_0}{2\Delta f_{0.7}} = \frac{5 \times 10^6}{150 \times 10^3} = \frac{100}{3}$$

$$\xi = Q_0 \frac{2\Delta f}{f_0} = \frac{100}{3} \times \frac{2 \times (5.5 - 5) \times 10^6}{5 \times 10^6} = \frac{20}{3}$$

$$2\Delta f'_{0.7} = 2 \times 2\Delta f_{0.7}, \quad Q'_0 = 0.5Q_0, \quad R' = 0.5R, \quad \text{所以应并上} 21k\Omega \text{电阻.}$$

$$3-8 \quad \therefore 4\pi\Delta f_{0.7} C = \frac{2\pi f_0 C}{f_0 / 2\Delta f_{0.7}} = \frac{\omega_0 C}{Q} = g_{\Sigma}$$

$$3-9 \quad \therefore C = C_i + \frac{(C_2 + C_0)C_1}{C_2 + C_0 + C_1} = 5 + \frac{(20 + 20)20}{20 + 20 + 20} = 18.3(\text{pF})$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.14 \sqrt{0.8 \times 10^{-6} \times 18.3 \times 10^{-12}}} = 41.6(\text{MHz})$$

$$R_p = Q_0 \sqrt{\frac{L}{C_{12}}} = 100 \times \sqrt{\frac{0.8 \times 10^{-6}}{(20 + 20) \times 10^{-12}}} = 20.9(\text{k}\Omega)$$

$$R_\Sigma = R_i \parallel R_p \parallel \left( \frac{C_2 + C_0 + C_1}{C_1} \right)^2 R_0 = 10 \parallel 20.9 \parallel \left( \frac{20 + 20 + 20}{20} \right)^2 \times 5 = 5.88(\text{k}\Omega)$$

$$Q_L = \frac{R_\Sigma}{\omega_0 L} = \frac{5.88 \times 10^3}{2 \times 3.14 \times 41.6 \times 10^6 \times 0.8 \times 10^{-6}} = 28.2$$

$$2Af_{0.7} = \frac{f_0}{Q_L} = \frac{41.6 \times 10^6}{28.2} = 1.48(\text{MHz})$$

3-12解:1)  $Z_{in} = 0$

2)  $Z_{in} = 0$

3)  $Z_{in} = R$

$$3-13 \quad \therefore 1) L_1 = L_2 = \frac{\rho_1}{\omega_{01}} = \frac{10^3}{2 \times 3.14 \times 10^6} = 159(\mu H)$$

$$C_1 = C_2 = \frac{1}{\omega_{01}^2 L_1} = \frac{1}{(2 \times 3.14 \times 10^6)^2 \times 159 \times 10^{-6}} = 159(pF)$$

$$M = \frac{\eta R_1}{\omega_{01}} = \frac{1 \times 20}{2 \times 3.14 \times 10^6} = 3.18(\mu H)$$

$$2) Z_{f_1} = \frac{(\omega_{01} M)^2}{R_2} = \frac{(2 \times 3.14 \times 10^6 \times 3.18 \times 10^{-6})^2}{20} = 20(\Omega)$$

$$Z_p = \frac{L_1}{(R_1 + R_{f_1}) C_1} = \frac{159 \times 10^{-6}}{(20 + 20) \times 159 \times 10^{-12}} = 25(k\Omega)$$

$$3) Q_1 = \frac{\omega_{01} L_1}{R_1 + R_{f_1}} = \frac{2 \times 3.14 \times 10^6 \times 159 \times 10^{-6}}{20 + 20} = 25$$

$$4) 2\Delta f_{0.7} = \sqrt{2} \frac{f_0}{Q} = \sqrt{2} \frac{f_0}{\rho_1 / R_1} = \sqrt{2} \times \frac{10^6 \times 20}{10^3} = 282(kHz)$$

$$5) C_2 = \frac{1}{(\omega'_{02})^2 L_2} = \frac{1}{(2 \times 3.14 \times 950 \times 10^3)^2 \times 159 \times 10^{-6}} = 177(pF)$$

$$Z_{22} = R_2 + j \left( \omega_{02} L_1 - \frac{1}{\omega_{02} C_2} \right)$$

$$= 20 + j \left( 2 \times 3.14 \times 10^6 \times 159 \times 10^{-6} - \frac{1}{2 \times 3.14 \times 10^6 \times 177 \times 10^{-12}} \right) = 20 + j100$$

$$Z_{f_1} = \frac{(\omega_{01} M)^2}{Z_{22}} = \frac{(2 \times 3.14 \times 10^6 \times 3.18 \times 10^{-6})^2}{20 + j100} = 0.768 - j3.84(\Omega)$$

$$3-15 \text{解:} \therefore R = \frac{L}{R_p C} = \frac{159 \times 10^{-6}}{50 \times 10^3 \times 159 \times 10^{-12}} = 20(\Omega) = R_1$$

$$\therefore R_{f_1} = 0 \rightarrow M = 0$$

$$Q = \sqrt{2} \frac{f_0}{2\Delta f_{0.7}} = \sqrt{2} \frac{10^6}{14 \times 10^3} = 100$$

$$3-16 \quad 1) R_{f1} = \frac{(\omega_{01} M)^2}{R_2} = \frac{(10^7 \times 10^{-6})^2}{5} = 20(\Omega)$$

$$R_{ab} = \frac{(\omega_{01} L)^2}{(R_1 + R_{f1})} = \frac{(10^7 \times 100 \times 10^{-6})^2}{5 + 20} = 40(k\Omega)$$

$$2) \eta = \frac{\omega_{01} M}{R_1} = \frac{10^7 \times 10^{-6}}{5} = 2$$

$$3) Q = \frac{\omega_{01} L}{R_1} = \frac{10^7 \times 100 \times 10^{-6}}{5} = 200$$

$$\frac{2\Delta f_{0.7}}{f_0} = \sqrt{\eta^2 + 2\eta - 1} \cdot \frac{1}{Q} = \sqrt{2^2 + 2 \times 2 - 1} \times \frac{1}{200} = 0.013$$

$$3-17 \quad \therefore \frac{I}{I_0} = \frac{1}{\sqrt{1 + \left(Q' \frac{2\Delta f}{f_0}\right)^2}} = \frac{1}{\sqrt{1 + \left(Q' \frac{10 \times 10^3}{300 \times 10^3}\right)^2}} = \frac{1}{1.25} \rightarrow Q' = 22.5$$

$$R = \frac{1}{Q\omega_0 C} = \frac{1}{22.5 \times 2 \times 3.14 \times 300 \times 10^3 \times 2000 \times 10^{-12}} = 11.8$$

$$\frac{I}{I_0} = \frac{1}{\sqrt{1 + \left(Q \frac{2\Delta f}{f_0}\right)^2}} = \frac{1}{\sqrt{1 + \left(Q \frac{10 \times 10^3}{300 \times 10^3}\right)^2}} = \frac{1}{\sqrt{2}} \rightarrow Q = 30$$

$$Q - Q' = 30 - 22.5 = 7.5$$

$$3-18 \quad \begin{cases} 2\omega = \frac{1}{\sqrt{L_2 C}} \\ \omega = \frac{1}{\sqrt{(L_1 + L_2) C}} \end{cases} \rightarrow \begin{cases} L_1 = 375 \mu H \\ L_2 = 125 \mu \end{cases}$$

### 第三章 高频小信号放大器

$$4-5 \text{解: 当 } f = 1 \text{ MHz} \quad , \quad \beta = \frac{\beta_0}{\sqrt{1 + \left(\frac{\beta_0 f}{f_T}\right)^2}} = \frac{50}{\sqrt{1 + \left(\frac{50 \times 10^6}{250 \times 10^6}\right)^2}} = 49$$

$$\text{当 } f = 20 \text{ MHz} \quad , \quad \beta = \frac{\beta_0}{\sqrt{1 + \left(\frac{\beta_0 f}{f_T}\right)^2}} = \frac{50}{\sqrt{1 + \left(\frac{50 \times 20 \times 10^6}{250 \times 10^6}\right)^2}} = 12.1$$

$$\text{当 } f = 50 \text{ MHz} \quad , \quad \beta = \frac{\beta_0}{\sqrt{1 + \left(\frac{\beta_0 f}{f_T}\right)^2}} = \frac{50}{\sqrt{1 + \left(\frac{50 \times 50 \times 10^6}{250 \times 10^6}\right)^2}} = 5$$

$$4-7\text{解: } g_{be} = \frac{I_E}{26(\beta_0 + 1)} = \frac{1}{26 \times (50 + 1)} = 0.754(mS)$$

$$g_m = \frac{\beta_0}{r_{be}} = 50 \times 0.754 \times 10^{-3} = 37.7(mS)$$

$$C_{be} = \frac{g_m}{2\pi f_T} = \frac{37.7 \times 10^{-3}}{2 \times 3.14 \times 250 \times 10^6} = 24(pF)$$

$$a = 1 + r_{bb'} g_{be} = 1 + 70 \times 0.754 \times 10^{-3} \approx 1$$

$$b = \omega C_{b'e} r_{bb'} = 2 \times 3.14 \times 10^7 \times 24 \times 10^{-12} \times 70 \approx 0.1$$

$$y_{ie} = \frac{(g_{be} + j\omega C_{b'e})(a - jb)}{a^2 + b^2} = \frac{(0.754 \times 10^{-3} + j2 \times 3.14 \times 10^7 \times 24 \times 10^{-12}) \times (1 - j0.1)}{1^2 + 0.1^2}$$

$$= 0.895 + j1.41(mS)$$

$$y_{re} = -\frac{(g_{bc} + j\omega C_{bc})(a - jb)}{a^2 + b^2} \approx -\frac{j2 \times 3.14 \times 10^7 \times 3 \times 10^{-12} \times (1 - j0.1)}{1^2 + 0.1^2} = -0.0187 - j0.187(mS)$$

$$y_{fe} = \frac{g_m(a - jb)}{a^2 + b^2} = \frac{37.7 \times 10^{-3} \times (1 - j0.1)}{1^2 + 0.1^2} = 37.327 - j3.733(mS)$$

$$y_{oe} = g_{ce} + j\omega C_{b'c} + r_{bb'} g_m \frac{(g_{bc} + j\omega C_{bc})(a - jb)}{a^2 + b^2} \approx j\omega C_{b'c} \left( 1 + r_{bb'} g_m \frac{a - jb}{a^2 + b^2} \right)$$

$$\approx j2 \times 3.14 \times 10^7 \times 3 \times 10^{-12} \left( 1 + 70 \times 37.7 \times 10^{-3} \times \frac{1 - j0.1}{1^2 + 0.1^2} \right) = 0.049 + j0.68(mS)$$

$$4-8\text{解: } \text{令} \left( \frac{A_v}{A_{vo}} \right)^m = \left( \frac{2}{\sqrt{4 + (Q2Af_{0.7}/f_0)^4}} \right)^m = \frac{1}{\sqrt{2}} \quad \text{得} 2Af_{0.7} = \sqrt[4]{4 \left( 2^{\frac{1}{m}} - 1 \right)} \cdot \frac{f_0}{Q}$$

$$\text{令} \left( \frac{A_v}{A_{vo}} \right)^m = \left( \frac{2}{\sqrt{4 + (Q2Af_{0.1}/f_0)^4}} \right)^m = \frac{1}{10} \quad \text{得} 2Af_{0.1} = \sqrt[4]{4 \left( 10^{\frac{2}{m}} - 1 \right)} \cdot \frac{f_0}{Q}$$

$$\text{故} K_{r0.1} = \frac{2Af_{0.1}}{2Af_{0.7}} = \frac{\sqrt[4]{4 \left( 10^{\frac{2}{m}} - 1 \right)}}{\sqrt[4]{4 \left( 2^{\frac{1}{m}} - 1 \right)}} = \sqrt[4]{\frac{10^{\frac{2}{m}} - 1}{2^{\frac{1}{m}} - 1}}$$

$$4-9 \text{解: } p_1 = \frac{N_{23}}{N_{13}} = \frac{5}{20} = 0.25 \quad p_2 = \frac{N_{45}}{N_{13}} = \frac{5}{20} = 0.25$$

$$g_p = \frac{1}{\omega_0 Q_0 L} = \frac{1}{2\pi \times 10.7 \times 10^6 \times 100 \times 4 \times 10^{-6}} = 37.2(\mu S)$$

$$g_\Sigma = g_p + p_1^2 g_{oe} + p_2^2 g_{ie} = 37.2 \times 10^{-6} + \frac{1}{4^2} \times 200 \times 10^{-6} + \frac{1}{4^2} \times 2860 \times 10^{-6} = 228.5(\mu S)$$

$$A_{vo} = \frac{p_1 p_2 |y_{fe}|}{g_\Sigma} = \frac{0.25 \times 0.25 \times 45 \times 10^{-3}}{228.5 \times 10^{-6}} = 12.3$$

$$A_{po} = A_{vo}^2 = 12.3^2 = 151.3$$

$$Q_L = \frac{1}{g_\Sigma \omega_0 L} = \frac{1}{228.5 \times 10^{-6} \times 2\pi \times 10.7 \times 10^6 \times 4 \times 10^{-6}} = 16.3$$

$$2Af_{0.7} = \frac{f_0}{Q_L} = \frac{10.7 \times 10^6}{16.3} = 0.657(MHz)$$

$$K = \left(1 - \frac{Q_L}{Q_0}\right)^{-2} = \left(1 - \frac{16.3}{100}\right)^{-2} = 1.43$$

$$\zeta = \tan \frac{\varphi_{fe} + \varphi_{re}}{2} = \tan \frac{-54^\circ - 88.5^\circ}{2} = -2.95$$

$$g'_L = \frac{g_p + p_2^2 g_{ie}}{p_1^2} = \frac{37.2 \times 10^{-6} + 0.25^2 \times 200 \times 10^{-6}}{0.25^2} = 3008.8(\mu S)$$

$$S = \frac{(g_s + g_{ie})(g_{oe} + g'_L)(1 + \zeta^2)}{|y_{fe}| |y_{re}|} = \frac{2 \times 2860 \times 10^{-6} (200 \times 10^{-6} + 3008.8 \times 10^{-6})(1 + 2.95^2)}{|45 \times 10^{-3}| |0.31 \times 10^{-3}|} \gg 1$$

$$4-10\text{解:}(1)g_p = \frac{1}{Q_0\omega_0 L} = \frac{1}{100 \times 2 \times 3.14 \times 10.7 \times 10^6 \times 4 \times 10^{-6}} = 0.037(\text{mS})$$

$$g_\Sigma = g_p + \frac{1}{R_s} + p_1^2 g_{oe} + p_2^2 g_{ie} = (0.037 + 0.1 + 0.3^2 \times 0.082 + 0.3^2 \times 0.15) = 0.158(\text{mS})$$

$$A_{vo} = \frac{p_1 p_2 y_{fe}}{g_\Sigma} = \frac{0.3 \times 0.3 \times \sqrt{38^2 + 4.2^2}}{0.158} = 21.78$$

$$(2)2Af_{0.7} = \omega_0 L g_\Sigma f_0 = 2 \times 3.14 \times (10.7 \times 10^6)^2 \times 4 \times 10^{-6} \times 0.158 \times 10^{-3} = 454.4(\text{kHz})$$

$$(3)(A_{vo})_4 = (A_{vo})^4 = 21.78^4 = 225025.38$$

$$(4)(2Af_{0.7})_4 = \sqrt{2^{\frac{1}{4}} - 1} \cdot 2Af_{0.7} = \sqrt{2^{\frac{1}{4}} - 1} \times 454.4 = 197.65(\text{kHz})$$

$$(5)2Af'_{0.7} = \frac{2Af_{0.7}}{\sqrt{2^{\frac{1}{4}} - 1}} = 1044.6(\text{kHz})$$

$$2Af'_{0.7} - 2Af_{0.7} = 1044.6 - 454.4 = 590.2(\text{kHz})$$

$$A'_{vo} = \frac{A_{vo} 2Af_{0.7}}{2Af'_{0.7}} = \frac{21.78 \times 454.4}{1044.6} = 9.47$$

$$(A'_{vo})_4 = (A'_{vo})^4 = 9.47^4 = 8042.66$$

$$(A_{vo})_4 - (A'_{vo})_4 = 225025.38 - 8042.66 = 216982.72$$

$$4-11\text{解: } C_\Sigma = C + p_1^2 C_{oe} = 500 + 0.3^2 \times 18 = 501.62(\text{pF})$$

$$L = \frac{1}{(2\pi f_0)^2 C_\Sigma} = \frac{1}{(2 \times 3.14 \times 15 \times 10^6)^2 \times 501.62 \times 10^{-12}} = 22.5(\mu\text{H})$$

$K_{r0.1} < 1.9$  不能满足

$$4-14\text{解:}(A_{vo})_S = \sqrt{\frac{|y_{fe}|}{2.5\omega_0 C_{re}}} = \sqrt{\frac{\sqrt{26.4^2 + 36.4^2}}{2.5 \times 0.3}} = 7.74$$



$$4-17\text{解: } L_1 = \frac{1}{\omega_0^2 C_1} = \frac{1}{(2\pi \times 465 \times 10^3)^2 \times 1000 \times 10^{-12}} = 118(\mu H)$$

$$L_{36} = L_2 + L_{34} + L_{56} = \frac{118}{73} + \frac{118}{73} \times 60 + \frac{118}{73} \times 13.5 = 120$$

$$C_{12} = C_1 + C_o = 1000 + 4 = 1004(pF)$$

$$C_{36} = C_2 + p_2^2 C_i = 1000 + \left(\frac{13.5}{74.5}\right)^2 \times 40 = 1004(pF)$$

$$g_{12} = g_o + \frac{\omega_0 C_1}{Q_0} = 20 \times 10^{-6} + \frac{2\pi \times 465 \times 10^3 \times 1000 \times 10^{-12}}{100} = 49(\mu S)$$

$$g_{36} = p_2^2 g_i + \frac{\omega_0 C_2}{Q_0} = \left(\frac{13.5}{74.5}\right)^2 \times 0.62 \times 10^{-3} + \frac{2\pi \times 465 \times 10^3 \times 1000 \times 10^{-12}}{100} = 49(\mu S)$$

∴ 初、次级回路参数相等。若为临界耦合，即  $\eta = 1$ ，则

$$A_{vo} = \frac{p_1 p_2 y_{fe}}{g} = \frac{1 \times \frac{13.5}{74.5} \times 40 \times 10^{-3}}{2 \times 49 \times 10^{-6}} = 74$$

$$Q_L = \frac{\omega_0 C_{12}}{g_{12}} = \frac{2\pi \times 465 \times 10^3 \times 1004 \times 10^{-12}}{49 \times 10^{-6}} = 60$$

$$2Af_{0.7} = \sqrt{2} \frac{f_0}{Q_L} = \sqrt{2} \times \frac{465 \times 10^3}{60} = 10.9(kHz)$$

$$K_{r0.1} = 3.16$$

$$4-20 \quad \sqrt{\overline{v_n^2}} = \sqrt{4kTR\mathcal{A}_n} = \sqrt{4 \times 1.38 \times 10^{-23} \times 290 \times 1000 \times 10^7} = 12.65(\mu V)$$

$$\sqrt{\overline{i_n^2}} = \sqrt{4kTG\mathcal{A}_n} = \sqrt{4 \times 1.38 \times 10^{-23} \times 290 \times 10^{-3} \times 10^7} = 12.65(nA)$$

$$4-21\text{解: } \overline{v_n^2} = \overline{v_{n1}^2} + \overline{v_{n2}^2} + \overline{v_{n3}^2} = 4kT_1 R_1 \mathcal{A}_n + 4kT_2 R_2 \mathcal{A}_n + 4kT_3 R_3 \mathcal{A}_n$$

$$= 4k(T_1 R_1 + T_2 R_2 + T_3 R_3) \mathcal{A}_n$$

$$= 4kT(R_1 + R_2 + R_3) \mathcal{A}_n$$

$$\therefore T = \frac{T_1 R_1 + T_2 R_2 + T_3 R_3}{R_1 + R_2 + R_3}$$

$$\therefore \overline{i_n^2} = \overline{i_{n1}^2} + \overline{i_{n2}^2} + \overline{i_{n3}^2} = 4kT_1 G_1 \mathcal{A}_n + 4kT_2 G_2 \mathcal{A}_n + 4kT_3 G_3 \mathcal{A}_n$$

$$= 4k(T_1 G_1 + T_2 G_2 + T_3 G_3) \mathcal{A}_n$$

$$= 4kT(G_1 + G_2 + G_3) \mathcal{A}_n$$

$$\therefore T = \frac{T_1 G_1 + T_2 G_2 + T_3 G_3}{G_1 + G_2 + G_3} = \frac{R_1 R_2 T_3 + R_2 R_3 T_1 + R_3 R_1 T_2}{R_1 R_2 + R_2 R_3 + R_3 R_1}$$

$$4-18 \text{证明:1)} \dot{I}_{b1} = y_{ie} \dot{V}_{be1} + y_{re} \dot{V}_{ce1} \dots\dots(1)$$

$$\dot{I}_{c1} = y_{fe} \dot{V}_{be1} + y_{oe} \dot{V}_{ce1} \dots\dots(2)$$

$$\dot{I}_{b2} = y_{ie} \dot{V}_{be2} + y_{re} \dot{V}_{ce2} = -y_{ie} \dot{V}_{ce1} + y_{re} (\dot{V}_{cb2} - \dot{V}_{ce1}) = y_{re} \dot{V}_{cb2} - (y_{ie} + y_{re}) \dot{V}_{ce1} \dots\dots(3)$$

$$\dot{I}_{c2} = y_{fe} \dot{V}_{be2} + y_{oe} \dot{V}_{ce2} = -y_{fe} \dot{V}_{ce1} + y_{oe} (\dot{V}_{cb2} - \dot{V}_{ce1}) = y_{oe} \dot{V}_{cb2} - (y_{fe} + y_{oe}) \dot{V}_{ce1} \dots\dots(4)$$

$$(2)-(3) \text{得} \dot{I}_{c2} = y_{fe} \dot{V}_{be1} + (y_{ie} + y_{re} + y_{oe}) \dot{V}_{ce1} - y_{re} \dot{V}_{cb2}$$

$$\dot{V}_{ce1} = \frac{\dot{I}_{c2} + y_{re} \dot{V}_{cb2} - y_{fe} \dot{V}_{be1}}{y_{ie} + y_{re} + y_{oe}} \dots\dots(5)$$

$$(5) \text{代入}(4) \dot{I}_{c2} = y_{oe} \dot{V}_{cb2} - (y_{fe} + y_{oe}) \frac{\dot{I}_{c2} + y_{re} \dot{V}_{cb2} - y_{fe} \dot{V}_{be1}}{y_{ie} + y_{re} + y_{oe}}$$

$$\dot{I}_{c2} = \frac{y_{ie} (y_{ie} + y_{oe})}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \dot{V}_{be1} + \frac{y_{ie} y_{oe} - y_{re} y_{ie} + y_{oe}^2}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \dot{V}_{cb2} \dots\dots(6)$$

$$\therefore y_i = \frac{y_{ie} (y_{ie} + y_{oe})}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \approx y_{ie}$$

$$y_o = \frac{y_{ie} y_{oe} - y_{re} y_{ie} + y_{oe}^2}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \approx -y_{re}$$

由(1)乘 $(y_{fe} + y_{oe})$ 与(4)乘 $y_{re}$ 后相加得

$$\dot{I}_{b1} (y_{fe} + y_{oe}) + \dot{I}_{c2} y_{re} = y_{ie} (y_{ie} + y_{oe}) \dot{V}_{be1} + y_{re} y_{oe} \dot{V}_{cb2}$$

由(6)代入消去 $\dot{I}_{c2}$ 得

$$\dot{I}_{b1} = \frac{y_{ie}^2 + y_{ie} y_{re} + y_{ie} y_{ie} + 2y_{ie} y_{oe} - y_{re} y_{ie}}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \dot{V}_{be1} + \frac{y_{re} (y_{oe} + y_{re})}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \dot{V}_{cb2}$$

$$y_i = \frac{y_{ie}^2 + y_{ie} y_{re} + y_{ie} y_{ie} + 2y_{ie} y_{oe} - y_{re} y_{ie}}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \approx y_{ie}$$

$$y_r = \frac{y_{re} (y_{oe} + y_{re})}{y_{ie} + y_{re} + y_{ie} + 2y_{oe}} \approx -\frac{y_{re} (y_{oe} + y_{re})}{y_{ie}}$$

同理可证2) 略

$$4-22 \text{解:} \overline{v_{bn}^2} = 4kTf_b \Delta f_n = 4 \times 1.38 \times 10^{-23} \times (273 + 19) \times 70 \times 200 \times 10^3 = 0.226 \times 10^{-12} (V^2)$$

$$\overline{i_{en}^2} = 2qI_E \Delta f_n = 2 \times 1.6 \times 10^{-19} \times 10^{-3} \times 200 \times 10^3 = 0.64 \times 10^{-16} (A^2)$$

$$|\alpha| = \frac{\alpha_0}{\sqrt{1 + \left(\frac{f}{f_\alpha}\right)^2}} = \frac{0.95}{\sqrt{1 + \left(\frac{10 \times 10^6}{500 \times 10^6}\right)^2}} = 0.95$$

$$\overline{i_{cn}^2} = 2qI_C (1 - \alpha_0) \Delta f_n = 2 \times 1.6 \times 10^{-19} \times 10^{-3} \times (1 - 0.95) \times 200 \times 10^3 = 0.32 \times 10^{-17} (A^2)$$

$$4-23 \text{ 证明: } \Delta f_n = \frac{\int_0^\infty A^2(f)df}{A^2(f_0)} = \int_0^\infty \frac{1}{1 + \left(2Q \frac{f-f_0}{f_0}\right)^2} df = \frac{\pi f_0}{2Q}$$

$$4-24 \text{ 解: } F_n = 3dB(1.995) \quad F_n = 6dB(3.981)$$

$$F_n = 1 + \frac{T_i}{T} = 1 + \frac{60}{290} = 1.207$$

$$F_n = F_n + \frac{F_n - 1}{A_p} + \frac{F_n - 1}{K_{pc} A_p} = 1.995 + \frac{1.207 - 1}{A_p} + \frac{3.981 - 1}{0.2 \times A_p} = 10$$

$$A_p = 1.888 \quad 20 \lg 1.888 = 2.76(dB)$$

$$4-25 \text{ 解: } F_n = \frac{P_{si}/P_{ni}}{P_{so}/P_{no}} = \frac{P_{no}}{P_{ni} A_p} = \frac{1}{A_p} = \frac{1}{P_o/P_s} = \frac{P_s}{P_o} = \frac{V_s^2/4R_s}{V_s^2/4(R_s + R)} = \frac{R_s + R}{R} = 1 + \frac{R_s}{R}$$

$$4-26 \text{ 解: } F_n = \frac{P_{si}/P_{ni}}{P_{so}/P_{no}} = \frac{1}{A_p} = \frac{P_s}{P_o} = \frac{I_s^2/4G_s}{I_s^2/4(G_s + G + G_L + rC/L)} = 1 + \frac{G + G_L + rC/L}{G_s}$$

4-27解: A为输入级, B为中间级, C为输出级。

$$A_{pA} = 6dB(3.981 \text{ 倍}) \quad A_{pB} = 12dB(15.849 \text{ 倍})$$

$$F_n = F_{nA} + \frac{F_{nB} - 1}{A_{pA}} + \frac{F_{nC} - 1}{A_{pA} \cdot A_{pB}} = 1.7 + \frac{2 - 1}{3.981} + \frac{4 - 1}{3.981 \times 15.849} = 2$$

4-28解: 不能满足要求。设A前置放大器, B为输入级, C为下一级。

$$F_n = \frac{P_{si}/P_{ni}}{P_{so}/P_{no}} = \frac{10^5}{10^4} \geq F_{nA} + \frac{F_{nB} - 1}{A_{pA}} + \frac{F_{nC} - 1}{A_{pA} \cdot A_{pB}} = F_{nA} + \frac{10 - 1}{10} + \frac{1.995 - 1}{10 \times 0.1} \rightarrow F_{nA} \leq 8.1$$

## 第四章 非线性电路、时变参量和变频器

$$5-8 \text{ 解: } i = kv^2 = k(V_0 + V_m \cos \omega_0 t)^2$$

$$= k \left( V_0^2 + 2V_0 V_m \cos \omega_0 t + \frac{1}{2} V_m^2 + \frac{1}{2} V_m^2 \cos^2 2\omega_0 t \right)$$

当  $V_m \ll V_0$  时,  $i \approx k(V_0^2 + 2V_0 V_m \cos \omega_0 t)$ , 该非线性元件就能近似当成线性元件来处理, 即当  $V_0$  较大时, 静态工作点选在抛物线上段接近线性部分, 然后当  $V_m$  很小时, 根据泰勒级数原则, 可认为信号电压在特性的线性范围内变化, 不会进入曲线弯曲部分, 故可只取其级数的前两项得到近似线性特性。

5-12解: 为了使 $i_c$ 中的二次谐波振幅达到最大值,  $\theta_c$ 应为 $60^\circ$ 。

$$\cos 60^\circ = \frac{V_{BZ} + V_{BB}}{V_m} = \frac{1}{2} \quad \therefore V_{BB} = \frac{1}{2}V_m - V_{BZ}$$

$$5-13解: i = \begin{cases} gV_m \cos \omega t & \text{当 } \cos \omega t > 0 \\ 0 & \text{当 } \cos \omega t < 0 \end{cases}$$

$$i = \sum_{n=0}^{\infty} I_n \cos n\omega t$$

$$I_0 = \frac{1}{2\pi} \int_{-\pi}^{+\pi} gV_m \cos \omega t d(\omega t) = \frac{1}{\pi} gV_m$$

$$I_1 = \frac{1}{\pi} \int_{-\pi}^{+\pi} gV_m \cos^2 \omega t d(\omega t) = \frac{1}{2} gV_m$$

$$I_n = \frac{1}{\pi} \int_{-\pi}^{+\pi} gV_m \cos \omega t \cos n\omega t d(\omega t) = \begin{cases} \frac{2}{\pi} gV_m \frac{1}{n^2 - 1} & n \text{ 为偶数} \\ 0 & n \text{ 为奇数} \end{cases}$$

5-15解:  $i = i_{D1} + i_{D2}$

$$i_{D1} = \begin{cases} gV_m \cos \omega t & \text{当 } \cos \omega t > 0 \\ 0 & \text{当 } \cos \omega t < 0 \end{cases} \quad i_{D2} = \begin{cases} gV_m \cos \omega t & \text{当 } \cos \omega t < 0 \\ 0 & \text{当 } \cos \omega t > 0 \end{cases}$$

$$i = \frac{2}{\pi} gV_m + \frac{4}{\pi} gV_m \sum_{k=1}^{\infty} \frac{(-1)^{k-1}}{(2k)^2 - 1} \cos 2k\omega_0 t \quad (k = 1, 2, 3, \dots)$$

5-16解: 当 $V_0(1 + m \sin \Omega t) \sin \omega_0 t < 0$ 时,  $i = 0$ ;

当 $V_0(1 + m \sin \Omega t) \sin \omega_0 t > 0$ 时,  $i = gV_0(1 + m \sin \Omega t) \sin \omega_0 t$

$$i = \frac{2}{\pi} gV_0 \left( 1 + m \sin \Omega t - 2 \sum_{k=1}^{\infty} \frac{\cos 2k\omega_0 t}{4k^2 - 1} - 2m \sum_{k=1}^{\infty} \frac{\sin \Omega t \cos 2k\omega_0 t}{4k^2 - 1} \right) \\ (k = 1, 2, 3, \dots)$$

5-17解:  $v_0 = R_L(i_{D1} - i_{D2}) = R_L [k(v_1 + v_2)^2 - k(v_1 - v_2)^2] = 4kR_L v_1 v_2$

$$5-18解: v_0 = R_L(i_2 - i_3) + R_L(i_4 - i_1) = R_L(i_2 + i_4 - i_1 - i_3) \\ = R_L [b_0 + b_1(v_1 - v_2) + b_2(v_1 - v_2)^2 + b_3(v_1 - v_2)^3] \\ + R_L [b_0 + b_1(-v_1 + v_2) + b_2(-v_1 + v_2)^2 + b_3(-v_1 + v_2)^3] \\ - R_L [b_0 + b_1(v_1 + v_2) + b_2(v_1 + v_2)^2 + b_3(v_1 + v_2)^3] \\ - R_L [b_0 + b_1(-v_1 - v_2) + b_2(-v_1 - v_2)^2 + b_3(-v_1 - v_2)^3] \\ = -8R_L b_2 v_1 v_2$$

$$5-23\text{解:}(1)g_m = \frac{di_C}{dv_{BE}} = b_1 + 2b_2v_{BE} + 3b_3v_{BE}^2 + 4b_4v_{BE}^3$$

$$g_m(t) = \left. \frac{di_C}{dv_{BE}} \right|_{v_{BE}=v_0} = b_1 + 2b_2V_{0m} \cos \omega_0 t + 3b_3V_{0m}^2 \cos^2 \omega_0 t + 4b_4V_{0m}^3 \cos^3 \omega_0 t$$

$$= b_1 + 2b_2V_{0m} \cos \omega_0 t + \frac{3}{2}b_3V_{0m}^2(1 + \cos 2\omega_0 t) + 2b_4V_{0m}^3 \cos \omega_0 t + b_4V_{0m}^3(\cos \omega_0 t + \cos 3\omega_0 t)$$

$$g_{m1} = 2b_2V_{0m} + 3b_4V_{0m}^3$$

$$g_c = \frac{1}{2}g_{m1} = b_2V_{0m} + 1.5b_4V_{0m}^3$$

$$(2)g_m = \frac{di_C}{dv_{BE}} = \frac{\alpha I_S q}{kT} v_{BE} \cdot e^{\frac{q}{kT}v_{BE}}$$

$$g_m(t) = \left. \frac{di_C}{dv_{BE}} \right|_{v_{BE}=v_0} = \frac{\alpha I_S q}{kT} V_{om} \cos \omega_0 t \cdot e^{\frac{q}{kT}V_{om} \cos \omega_0 t}$$

$$= \frac{\alpha I_S q}{kT} V_{om} \cos \omega_0 t \left[ 1 + \frac{q}{kT} V_{om} \cos \omega_0 t + \frac{1}{2} \left( \frac{q}{kT} V_{om} \cos \omega_0 t \right)^2 + \frac{1}{6} \left( \frac{q}{kT} V_{om} \cos \omega_0 t \right)^3 + \dots \right]$$

$$= \alpha I_S \frac{qV_{om}}{kT} \cos \omega_0 t + \alpha I_S \left( \frac{qV_{om}}{kT} \right)^2 \cos^2 \omega_0 t + \frac{\alpha I_S}{2} \left( \frac{qV_{om}}{kT} \right)^3 \cos^3 \omega_0 t + \frac{\alpha I_S}{6} \left( \frac{qV_{om}}{kT} \right)^4 \cos^4 \omega_0 t$$

$$g_{m1} \approx \alpha I_S \frac{qV_{om}}{kT} + \frac{3\alpha I_S}{8} \left( \frac{qV_{om}}{kT} \right)^3$$

$$g_c = \frac{1}{2}g_{m1} = \frac{\alpha I_S qV_{om}}{2kT} + \frac{3\alpha I_S}{16} \left( \frac{qV_{om}}{kT} \right)^3$$

$$5-25\text{解: } i_\Sigma = i_1 - i_3 + i_2 - i_4$$

$$= a_0 + a_1(v_0 + v_s) + a_2(v_0 + v_s)^2 + a_3(v_0 + v_s)^3 + a_4(v_0 + v_s)^4 + \dots$$

$$+ a_0 + a_1(v_0 - v_s) + a_2(v_0 - v_s)^2 + a_3(v_0 - v_s)^3 + a_4(v_0 - v_s)^4 + \dots$$

$$- a_0 - a_1(-v_0 + v_s) - a_2(-v_0 + v_s)^2 - a_3(-v_0 + v_s)^3 - a_4(-v_0 + v_s)^4 - \dots$$

$$- a_0 - a_1(-v_0 - v_s) - a_2(-v_0 - v_s)^2 - a_3(-v_0 - v_s)^3 - a_4(-v_0 - v_s)^4 - \dots$$

$$= 8a_2v_0v_s + 16a_4v_0^3v_s + 16a_4v_s^3v_0 + \dots$$

$$5-29\text{解: } g_c = 0.5 \frac{I_E/26}{\sqrt{1 + \left( \frac{\omega_s}{\omega_T} \cdot \frac{I_E}{26} r_{bb} \right)^2}} \approx \frac{0.5I_E}{26} = \frac{0.5 \times 0.5}{26} = 9.6(mS)$$

$$g_{ic} \approx g_{b'e} = \frac{I_E}{26\beta_0} = \frac{0.5}{26 \times 35} = 0.55(mS)$$

$$g_{oc} \approx g_{ce} = 4(\mu S)$$

$$A_{pc\max} = \frac{g_c^2}{4g_{ic}g_{oc}} = \frac{9.6^2}{4 \times 0.55 \times 0.004} = 10473(\approx 40dB)$$

$$A_{pc} = A_{pc\max} \left(1 - \frac{Q_L}{Q_0}\right)^2 = A_{pc\max} \left(1 - \frac{\sqrt{2}f_i}{Q_0 2\Delta f_{0.7}}\right)^2 = 10473 \times \left(1 - \frac{\sqrt{2} \times 465}{100 \times 10}\right)^2 = 1228(\approx 30.1dB)$$

$$5-30\text{解: } g_c = 0.5 \frac{I_E/26}{\sqrt{1 + \left( \frac{\omega_s}{\omega_T} \cdot \frac{I_E}{26} r_{bb} \right)^2}} \approx \frac{0.5I_E}{26} = \frac{0.5 \times 0.08}{26} = 1.54(mS)$$

$$g_{ic} \approx g_{b'e} = \frac{I_E}{26\beta_0} = \frac{0.08}{26 \times 30} = 0.1(mS)$$

$$g_{oc} \approx g_{ce} = 10(\mu S)$$

$$A_{pc\max} = \frac{g_c^2}{4g_{ic}g_{oc}} = \frac{1.54^2}{4 \times 0.1 \times 0.01} = 592.9(\approx 28dB)$$

$$A_{pc} = \left(\frac{g_c}{g_{oc} + G_L}\right)^2 \cdot \frac{G_L}{g_{ic}} = \left(\frac{1.54}{0.01 + 0.1}\right)^2 \times \frac{0.1}{0.1} = 196(\approx 23dB)$$

$$5-32\text{解: } i_\Sigma = i_1 - i_2 - i_3 + i_4$$

$$\begin{aligned} &= a_0 + a_1(v_0 + v_s) + a_2(v_0 + v_s)^2 + a_3(v_0 + v_s)^3 + a_4(v_0 + v_s)^4 + \dots \\ &- \left[ a_0 + a_1(v_0 - v_s) + a_2(v_0 - v_s)^2 + a_3(v_0 - v_s)^3 + a_4(v_0 - v_s)^4 + \dots \right] \\ &- \left[ a_0 + a_1(-v_0 + v_s) + a_2(-v_0 + v_s)^2 + a_3(-v_0 + v_s)^3 + a_4(-v_0 + v_s)^4 + \dots \right] \\ &+ \left[ a_0 + a_1(-v_0 - v_s) + a_2(-v_0 - v_s)^2 + a_3(-v_0 - v_s)^3 + a_4(-v_0 - v_s)^4 + \dots \right] \\ &= 8a_2v_0v_s + 16a_4v_0^3v_s + 16a_4v_s^3v_0 + \dots \end{aligned}$$

5-34解: 因存在二次项, 能进行混频。只要满足 $f_n = f_i$ 就会产生中频干扰; 当 $f_n = f_0 + f_i$ 时产生镜像干扰。由于不存在三次项, 不会产生交调干扰; 有二次项, 可能产生互调干扰; 若有强干扰信号, 则能产生阻塞干扰。

- 5-35解:1. 此现象属于组合频率干扰。这是由于混频器的输出电流中,除需要的中频电流外,还存在一些谐波频率和组合频率,如果这些组合频率接近于中频放大的通带内,它就能和有用中频一道进入中频放大器,并被放大后加到检波器上,通过检波器的非线性效应,与中频差拍检波,产生音频,最终出现哨叫声。
2. 因 $f_1 = 465\text{kHz}$ ,  $p$ 、 $q$ 为本振和信号的谐波次数,不考虑大于3的情况。所以落于 $535 \sim 1605\text{kHz}$ 波段内的干扰在 $f_s = 930\text{kHz}$ 和 $f_s = 1395\text{kHz}$ 附近,1kHz的哨叫声在 $929\text{kHz}$ 、 $931\text{kHz}$ 、 $1394\text{kHz}$ 、 $1396\text{kHz}$ 时产生。
3. 提高前端电路的选择性,合理选择中频等。

5-36解:若满足 $|\pm pf_1 \pm qf_2| = f_s$ ,则会产生互调干扰:

- $p = 1$ 、 $q = 1$ ,  $f_1 + f_2 = 774 + 1035 = 1.809(\text{MHz})$ ,不会产生互调干扰;  
 $p = 1$ 、 $q = 2$ ,  $f_1 + 2f_2 = 774 + 2 \times 1035 = 2.844(\text{MHz})$ ,会产生互调干扰;  
 $p = 2$ 、 $q = 1$ ,  $2f_1 + f_2 = 2 \times 774 + 1035 = 2.583(\text{MHz})$ ,会产生互调干扰;  
 $p = 2$ 、 $q = 2$ ,  $2(f_1 + f_2) = 2 \times (774 + 1035) = 3.618(\text{MHz})$ ,会产生互调干扰;  
 $p = 2$ 、 $q = 3$ ,  $2f_1 + 3f_2 = 2 \times 774 + 3 \times 1035 = 4.653(\text{MHz})$ ,会产生互调干扰;  
 $p = 3$ 、 $q = 2$ ,  $3f_1 + 2f_2 = 3 \times 774 + 2 \times 1035 = 4.392(\text{MHz})$ ,会产生互调干扰;  
 $p = 3$ 、 $q = 3$ ,  $3(f_1 + f_2) = 3 \times (774 + 1035) = 5.427(\text{MHz})$ ,会产生互调干扰;  
 $p$ 、 $q$ 大于3谐波较小,可以不考虑。

5-37解:(1) 
$$\begin{cases} 3f_s + 2f_0 < 2 \\ 2f_s + 3f_0 < 2 \end{cases} \Rightarrow f_s + f_0 < 0.8(\text{MHz})$$

$$\begin{cases} -f_s + 2f_0 < 2 \\ -2f_s + 3f_0 < 2 \end{cases} \Rightarrow -f_s + f_0 < 0.4(\text{MHz})$$

$$\therefore f_s = 0.2\text{MHz} \quad f_0 < 0.6\text{MHz}$$

(2) 
$$\begin{cases} -3f_s + 2f_0 > 30 \\ -2f_s + 3f_0 > 30 \end{cases} \Rightarrow -f_s + f_0 > 12(\text{MHz})$$

$$\begin{cases} f_s + 2f_0 > 30 \\ 2f_s + f_0 > 30 \end{cases} \Rightarrow f_s + f_0 > 20(\text{MHz})$$

$$\therefore f_s = 4\text{MHz} \quad f_0 > 16\text{MHz}$$

5-39解:若满足 $|\pm pf_1 \pm qf_2| = f_s$ ,则会产生互调干扰。已知 $f_1 = 19.6\text{MHz}$ 、 $f_2 = 19.2\text{MHz}$ 、 $f_s = f_0 - f_1 = 23 - 3 = 20(\text{MHz})$ ,故没有互调信号输出。

## 第五章 高频公路放大器

6-4解:  $P_{\Sigma} = V_{CC} I_{CO} = 24 \times 0.25 = 6(W)$

$$\eta_c = \frac{P_0}{P_{\Sigma}} = \frac{5}{6} = 83.3\%$$

$$R_p = \frac{V_{cm}^2}{2P_0} = \frac{V_{CC}^2}{2P_0} = \frac{24^2}{2 \times 5} = 57.6(\Omega)$$

$$I_{cm1} = \frac{2P_0}{V_{cm}} = \frac{2P_0}{V_{CC}} = \frac{2 \times 5}{24} = 0.417(A)$$

$$g_c(\theta_c) = \frac{I_{cm1}}{I_{c0}} = \frac{0.42}{0.25} = 1.67$$

查表得  $\theta_c = 77^\circ$

6-6解:  $g_c(\theta_c) = \frac{2\eta V_{CC}}{V_{cm}} = \frac{2 \times 0.7 \times 12}{10.8} = 1.56$  查表得  $\theta_c = 91^\circ$

$$P_0 = I_k^2 R = 2^2 \times 1 = 4(W)$$

$$P_c = P_{\Sigma} - P_0 = \left(\frac{1}{\eta_c} - 1\right) P_0 = \left(\frac{1}{0.7} - 1\right) \times 4 = 1.7(W)$$

6-7解:  $i_{c\max} = \frac{I_{c0}}{\alpha_0(90^\circ)} = \frac{90}{0.319} = 282(mA)$

$$I_{c1m} = \alpha_1(90^\circ) i_{c\max} = 0.5 \times 282 = 141(mA)$$

$$P_0 = \frac{1}{2} R_p I_{c1m}^2 = \frac{1}{2} \times 200 \times 0.141^2 = 2(W)$$

$$\eta_c = \frac{P_0}{V_{CC} I_{c0}} = \frac{2}{30 \times 0.09} = 74\%$$

6-8证:  $P_0 = \frac{V_{cm}^2}{2R_p} = \frac{I_{km}^2 [R^2 + (\omega_0 L)^2]}{\frac{2L}{RC}} = \frac{I_{km}^2 [R^2 + (\omega_0 L)^2] RC}{2L} = \frac{I_{km}^2 [R^2 + (\omega_0 L)^2] R}{2(\omega_0 L)^2} \approx \frac{I_{km}^2 R}{2}$



$$6-9\text{解: } V_{cm} = V_{CC} - v_{e\min} = V_{CC} - \frac{i_{e\max}}{g_{cr}} = 24 - \frac{2.2}{0.8} = 21.25(V)$$

$$I_{c0} = i_{e\max} \alpha_0(70^\circ) = 2.2 \times 0.253 = 0.5566(A)$$

$$I_{cm1} = i_{e\max} \alpha_1(70^\circ) = 2.2 \times 0.436 = 0.9592(A)$$

$$P_{\Sigma} = V_{CC} I_{c0} = 24 \times 0.5566 = 13.36(W)$$

$$P_0 = \frac{1}{2} V_{cm} I_{cm1} = \frac{1}{2} \times 21.25 \times 0.9592 = 10.19(W)$$

$$P_C = P_{\Sigma} - P_0 = 13.36 - 10.19 = 3.17(W)$$

$$\eta_C = \frac{P_0}{P_{\Sigma}} = \frac{10.19}{13.36} = 76.3\%$$

$$R_p = \frac{V_{cm}^2}{2P_0} = \frac{21.25^2}{2 \times 10.19} = 22.16(\Omega)$$

$$6-10\text{解: } R_1 = R_p = \frac{V_{cm}^2}{2P_0} \approx \frac{V_{CC}^2}{2P_0} = \frac{24^2}{2 \times 2} = 144(\Omega)$$

$$X_{C1} = \frac{R_1}{Q_L} = \frac{144}{10} = 14.4(\Omega)$$

$$C_1 = \frac{1}{2\pi f X_{C1}} = \frac{1}{2 \times 3.14 \times 50 \times 10^6 \times 14.4} = 221(pF)$$

$$X_{L1} = \frac{R_2}{\sqrt{\frac{R_2}{R_1}(Q_L^2 + 1) - 1}} = \frac{200}{\sqrt{\frac{200}{144} \times (100 + 1) - 1}} = 16.95(\Omega)$$

$$L_1 = \frac{X_{L1}}{2\pi f} = \frac{16.95}{2 \times 3.14 \times 50 \times 10^6} = 0.054(\mu H)$$

$$X_{C2} = \frac{Q_L R_1}{Q_L^2 + 1} \left( \frac{R_2}{Q_L X_{L1}} - 1 \right) = \frac{10 \times 144}{100 + 1} \left( \frac{200}{10 \times 16.95} - 1 \right) = 2.57(\Omega)$$

$$C_2 = \frac{1}{2\pi f X_{C2}} = \frac{1}{2 \times 3.14 \times 50 \times 10^6 \times 2.57} = 1239(pF)$$

6-11解:(1) $R_p$ 增加一倍, 放大器工作于过压状态,  $V_{cm}$ 变化不大,  $P'_0 = V_{cm}^2 / 2R_p = 0.5P_0$ ;

(2) $R_p$ 减小一半, 放大器工作于欠压状态,  $I_{cm}$ 变化不大,  $P'_0 = I_{cm}^2 R_p / 2 = 2P_0$ 。

$$6-12\text{解: } \eta_k = \frac{r'}{r_1 + r'} = \frac{1}{1 + \frac{\omega L_1 \omega L_2}{Q_1 Q_2 (\omega M)^2}} = \frac{1}{1 + \frac{1}{Q_1 Q_2 k^2}} = \frac{1}{1 + \frac{1}{100 \times 15 \times 0.03^2}} = 57.4\%$$

$$6-13 \text{解: } R_p = \frac{V_{cm}^2}{2P_0} = \frac{(V_{CC} - V_{CE(sat)})^2}{2P_0} = \frac{(12 - 0.5)^2}{2 \times 1} = 66(\Omega)$$

$$\text{设 } Q_L = 10 \quad \text{则 } X_{C1} = \frac{R_p}{Q_L} = \frac{66}{10} = 6.6(\Omega)$$

$$C_1 = \frac{1}{2\pi f X_{C1}} = \frac{1}{2 \times 3.14 \times 10^8 \times 6.6} = 241(pF)$$

$$X_{C2} = \frac{R_L}{\sqrt{(1 + Q_L^2) \frac{R_L}{R_p} - 1}} = \frac{50}{\sqrt{(1 + 10^2) \times \frac{50}{66} - 1}} = 5.5(\Omega)$$

$$C_2 = \frac{1}{2\pi f X_{C2}} = \frac{1}{2 \times 3.14 \times 10^8 \times 5.5} = 290(pF)$$

$$X_{L1} = \frac{Q_L R_p}{Q_L^2 + 1} \left( 1 + \frac{R_L}{Q_L X_{C2}} \right) = \frac{10 \times 66}{10^2 + 1} \left( 1 + \frac{50}{10 \times 5.5} \right) = 12.5(\Omega)$$

$$L_1 = \frac{X_{L1}}{2\pi f} = \frac{12.5}{2 \times 3.14 \times 10^8} = 19.9(nH)$$

6-14证:(a)将 $R_1C_1$ 和 $R_2C_2$ 串联电路改为 $R'_1C'_1$ 和 $R'_2C'_2$ 并联电路, 并设 $X_{C1} = \frac{R_1}{Q_L}$

$$R'_1 = \frac{X_{C1}^2}{R_1^2 + X_{C1}^2} R_1 \quad R'_2 = \frac{X_{C2}^2}{R_2^2 + X_{C2}^2} R_2 \quad X'_{C1} = \frac{R_1^2}{R_1^2 + X_{C1}^2} X_{C1} \quad X'_{C2} = \frac{R_2^2}{R_2^2 + X_{C2}^2} X_{C2}$$

$$\text{匹配时 } R'_1 = R'_2, \text{ 即 } R'_1 = \frac{X_{C1}^2}{R_1^2 + X_{C1}^2} R_1 = \frac{1}{1 + Q_L^2} R_1 = \frac{X_{C2}^2}{R_2^2 + X_{C2}^2} R_2$$

$$\therefore X_{C2} = \frac{R_2}{\sqrt{(1 + Q_L^2) \frac{R_2}{R_1} - 1}}$$

$$\begin{aligned} X_{L1} &= X'_{C1} + X'_{C2} = \frac{R_1^2}{R_1^2 + X_{C1}^2} X_{C1} + \frac{R_2^2}{R_2^2 + X_{C2}^2} X_{C2} \\ &= \frac{R_1^2}{R_1^2 + X_{C1}^2} X_{C1} + \frac{X_{C1}^2}{R_1^2 + X_{C1}^2} \cdot \frac{R_1 R_2}{X_{C2}} = \frac{R_1 Q_L}{1 + Q_L^2} + \frac{1}{1 + Q_L^2} \cdot \frac{R_1 R_2}{X_{C2}} = \frac{R_1 Q_L}{1 + Q_L^2} \left( 1 + \frac{R_2}{Q_L X_{C2}} \right) \end{aligned}$$

(b)将 $R_1C_1$ 和 $R_2L_1$ 串联电路改为 $R'_1C'_1$ 和 $R'_2L'_1$ 并联电路, 并设 $X_{C1} = \frac{R_1}{Q_L}$

$$R'_1 = \frac{X_{C1}^2}{R_1^2 + X_{C1}^2} R_1 \quad R'_2 = \frac{X_{L1}^2}{R_2^2 + X_{L1}^2} R_2 \quad X'_{C1} = \frac{R_1^2}{R_1^2 + X_{C1}^2} X_{C1} \quad X'_{L1} = \frac{R_2^2}{R_2^2 + X_{L1}^2} X_{L1}$$

$$\text{匹配时 } R'_1 = R'_2, \text{ 即 } R'_1 = \frac{X_{C1}^2}{R_1^2 + X_{C1}^2} R_1 = \frac{1}{1 + Q_L^2} R_1 = \frac{X_{L1}^2}{R_2^2 + X_{L1}^2} R_2$$

$$\therefore X_{L1} = \frac{R_2}{\sqrt{(1 + Q_L^2) \frac{R_2}{R_1} - 1}}$$

$$\begin{aligned} X_{C2} &= X'_{L1} - X'_{C1} = \frac{R_2^2}{R_2^2 + X_{L1}^2} X_{L1} - \frac{R_1^2}{R_1^2 + X_{C1}^2} X_{C1} \\ &= \frac{X_{C1}^2}{R_1^2 + X_{C1}^2} \cdot \frac{R_1 R_2}{X_{L1}} - \frac{R_1 Q_L}{1 + Q_L^2} = \frac{R_1 Q_L}{1 + Q_L^2} \cdot \frac{R_2}{Q_L X_{L1}} - \frac{R_1 Q_L}{1 + Q_L^2} = \frac{R_1 Q_L}{1 + Q_L^2} \left( \frac{R_2}{Q_L X_{L1}} - 1 \right) \end{aligned}$$

6-18解:(1)天线断开, 工作于过压状态, 集电极直流电表读数减小, 天线电流表读数为0;

(2)天线接地, 工作于欠压状态, 集电极直流电表读数略增, 天线电流表读数增加;

(3)中介回路失谐, 工作于欠压状态, 集电极直流电表读数略增, 天线电流表读数减小。

6-19解:(1) $P_A = P_{\Sigma} - P_C - P_k = 10 - 3 - 1 = 6(W)$

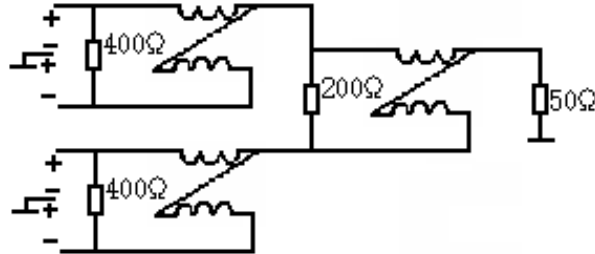
$$(2) \eta_k = \frac{P_A}{P_{\Sigma} - P_C} = \frac{6}{10 - 3} = 85.7\%$$

$$(3) \eta_c = \frac{P_{\Sigma} - P_C}{P_{\Sigma}} = \frac{10 - 3}{10} = 70\% \quad \eta = \frac{P_A}{P_{\Sigma}} = \frac{6}{10} = 60\%$$

6-20解: 当 $k = k_c$ 时,  $\eta_k = 1 - \frac{r_1}{r_1 + r'} = 50\%$ 则 $r' = r_1$       $k_c = \frac{1}{Q}$

若 $\eta'_k = 1 - \frac{r_1}{r_1 + r''} = 90\%$ 则 $r'' = 9r_1$ 故 $k = \frac{1}{\sqrt{Q_1 Q_2}} = \frac{1}{\sqrt{Q_0 \frac{Q_0}{9}}} = \frac{3}{Q} = 3k_c$

6-25解:



6-27解:  $\because \alpha_2(60^\circ) < \alpha_1(60^\circ), \therefore P_0$ 减小, 工作于欠压状态。

6-28解:  $R_i = \frac{V}{I} = 9 \frac{3}{3I} = 9R_L$

6-29解:  $V_{bm} = \frac{V_{BZ} + V_{BB}}{\cos \theta} = \frac{0.6 + 1.45}{\cos 70^\circ} = 6(V)$

$$V_B = V_{bm} - V_{BB} = 6 - 1.45 = 4.55(V)$$

$$i_{Cmax} = \frac{V_B - V_{BZ}}{2} = \frac{4.55 - 0.6}{2} = 1.98(A)$$

$$I_{cm1} = i_{Cmax} \alpha_1(70^\circ) = 1.98 \times 0.436 = 0.86(A)$$

$$V_{cm} = V_{CC} - g_{cr} i_{Cmax} = 24 - 1.98 = 22.02(V)$$

$$P_0 = \frac{I_{cm1} V_{cm}}{2} = \frac{0.86 \times 22.01}{2} = 9.47(W)$$

$$P_A = \left(1 - \frac{Q_L}{Q_0}\right) P_0 = \left(1 - \frac{10}{100}\right) \times 9.47 = 8.52(W)$$

$$6-30\text{解: } V_{bm} = \frac{V_{BZ} + V_{BB}}{\cos \theta} = \frac{0.6 + 1.5}{\cos 70^\circ} = 6.14(V)$$

$$V_B = V_{bm} - V_{BB} = 6.14 - 1.5 = 4.64(V)$$

$$i_{C_{\max}} = \frac{V_B - V_{BZ}}{2} = \frac{4.64 - 0.6}{2} = 2.02(A)$$

$$I_{cm1} = i_{C_{\max}} \alpha_1(70^\circ) = 2.02 \times 0.436 = 0.88(A)$$

$$V_{cm} = \xi V_{CC} = 0.9 \times 24 = 21.6(V)$$

$$P_0 = \frac{I_{cm1} V_{cm}}{2} = \frac{0.88 \times 21.6}{2} = 9.5(W)$$

$$P_A = \left(1 - \frac{Q_L}{Q_0}\right) P_0 = \left(1 - \frac{10}{100}\right) \times 9.5 = 8.8(W)$$

## 第六章 正弦选频网络

7-5解:(a)电路可能振荡,属于电感反馈式振荡电路;

(e)电路可能振荡,属于电容反馈式振荡电路;

(h)电路可能振荡,属于电容反馈式振荡电路;

(b),(c),(d)电路不可能振荡;

(f)电路在 $L_2 C_2 < L_3 C_3$ 时有可能振荡,属于电容反馈式振荡电路

(g)电路计及 $C_{be}$ 可能振荡,属于电容反馈式振荡电路。

7-6解:(1)有可能振荡,属于电容反馈式振荡电路,  $f_1 < f_2 < f_0 < f_3$ ;

(2)有可能振荡,属于电感反馈式振荡电路,  $f_1 > f_2 > f_0 > f_3$ ;

(4)有可能振荡;属于电容反馈式振荡电路,  $f_1 = f_2 < f_0 < f_3$ ;

(3)(5)(6)不可能。

7-7解:

$$7-21\text{解:(1)} f_0 = \frac{1}{2\pi\sqrt{L(C+C_d)}} = \frac{1}{2 \times 3.14 \times \sqrt{10^{-7} \times (20+5) \times 10^{-12}}} = 100(MHz)$$

$$(2) g_d = \frac{1}{R_p} = \frac{1}{Q} \sqrt{\frac{C}{L}} = \frac{1}{3} \times \sqrt{\frac{(20+5) \times 10^{-12}}{10^{-7}}} = 5.27(mS)$$

$$(3) 0.06 \sim 0.08V$$

$$7-26\text{解:}(1)f_q = \frac{1.657 \times 10^6}{d} = \frac{1.657 \times 10^6}{0.4} = 4.14(\text{MHz})$$

$$C_q = 21.1 \times 10^{-5} \frac{S}{d} = 21.1 \times 10^{-5} \times \frac{200}{0.4} = 0.105(\text{pF})$$

$$L_q = 43.5 \frac{d^3}{S} = 43.5 \times \frac{0.4^3}{200} = 14(\text{mH})$$

$$r_d = 42500 B \frac{d}{S} = 42500 \times 0.25 \times \frac{0.4}{200} = 21.2(\Omega)$$

$$C_0 = 3.96 \times 10^{-2} \frac{S}{d} = 3.96 \times 10^{-2} \times \frac{200}{0.4} = 19.8(\text{pF})$$

$$Q_q = \frac{1.05}{B} \times 10^4 d = \frac{1.05}{0.25} \times 10^4 \times 0.4 = 16800$$

$$(2)d = \frac{1.657 \times 10^6}{f_q} = \frac{1.657 \times 10^6}{15 \times 10^6} = 0.11(\text{mm})$$

7-27解:(1)1.5 ~ 1.5001(MHz)

(2)不能

(3)不能, 普通三极管没有负阻特性。

7-28解: 恒温槽、稳压电源、高稳定度克拉泼振荡电路、共集电极缓冲级等。

7-29解: 并联-b型(皮尔斯)晶体振荡电路。

## 第七章 振幅调制与解调

9-3解:  $i = I(1 + m_a \cos \Omega t) \cos \omega_0 t$

$$= I \cos \omega_0 t + \frac{I}{2} m_a \cos(\omega_0 + \Omega)t + \frac{I}{2} m_a \cos(\omega_0 - \Omega)t$$

$$I = \sqrt{\left(\frac{I}{\sqrt{2}}\right)^2 + \left(\frac{I}{2\sqrt{2}} m_a\right)^2 + \left(\frac{I}{2\sqrt{2}} m_a\right)^2}$$

$$= \frac{I}{\sqrt{2}} \sqrt{1 + \frac{m_a^2}{2}}$$

$$\begin{aligned}
 9-4 \text{解:} (1) v &= 25(1 + 0.7 \cos 2\pi 5000t - 0.3 \cos 2\pi 10000t) \sin 2\pi 10^6 t \\
 &= 25 \sin 2\pi 10^6 t + 8.75(\sin 2\pi 1005000 + \sin 2\pi 995000) \\
 &\quad - 3.75(\sin 2\pi 1010000 + \sin 2\pi 990000)
 \end{aligned}$$

$$(2) \text{包络 } 25(1 + 0.7 \cos 2\pi 5000t - 0.3 \cos 2\pi 10000t)$$

$$\text{峰值调幅度 } m = \frac{V_{\max} - V_0}{V_0} = \frac{25 \times (1 + 0.7 - 0.3) - 25}{25} = 0.4$$

$$\text{谷值调幅度 } m = \frac{V_0 - V_{\min}}{V_0} = \frac{25 - 25(1 - 0.7 - 0.3)}{25} = 1$$

$$9-5 \text{解:} (1) m_a = 1 \quad P_{(\omega_0+\Omega)} = P_{(\omega_0-\Omega)} = \frac{1}{4} m_a^2 P_{0T} = \frac{1}{4} \times 100 = 25(W)$$

$$(2) m_a = 0.3 \quad P_{(\omega_0+\Omega)} = P_{(\omega_0-\Omega)} = \frac{1}{4} m_a^2 P_{0T} = \frac{1}{4} \times 0.3^2 \times 100 = 2.25(W)$$

9-6解:  $i = b_1 v + b_3 v^3$  不包含平方项, 不能产生调幅作用。

$$9-7 \text{解:} (1) P_{(\omega_0+\Omega)} = P_{(\omega_0-\Omega)} = \frac{1}{4} m_a^2 P_{0T} = \frac{1}{4} \times 0.7^2 \times 5000 = 612.5(W)$$

$$P_{(\omega_0\pm\Omega)} = 2P_{(\omega_0+\Omega)} = 1225(W)$$

$$(2) P_{\pm} = \frac{P_{0av}}{\eta} = \frac{P_{0T}}{\eta} = \frac{5000}{0.5} = 10(kW)$$

$$(3) P_{\pm} = \frac{P_{0av}}{\eta} = \frac{P_{0T} \left(1 + \frac{m_a^2}{2}\right)}{\eta} = \frac{5000 \times \left(1 + \frac{0.7^2}{2}\right)}{0.5} = 12.45(kW)$$

$$9-8 \text{解:} (1) m_a = 1 \text{ 时}$$

$$P_{(\omega_0+\Omega)} = P_{(\omega_0-\Omega)} = \frac{1}{4} m_a^2 P_{0T} = \frac{1}{4} \times 1000 = 250(W)$$

$$P_0 = P_{0T} + P_{(\omega_0+\Omega)} + P_{(\omega_0-\Omega)} = 1000 + 250 + 250 = 1500(W)$$

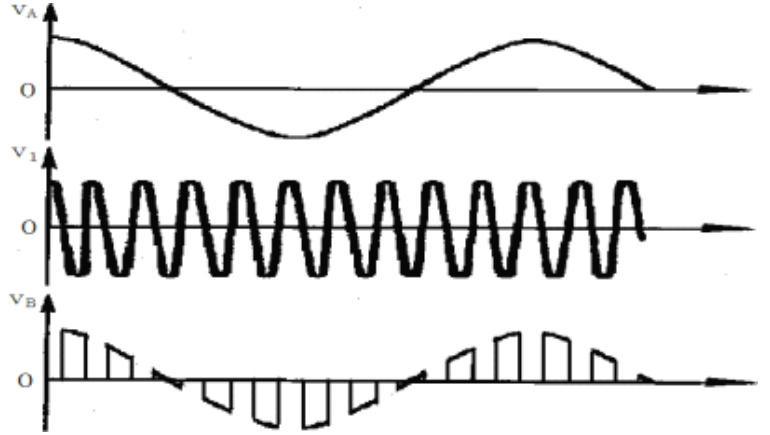
$$(2) m_a = 0.7 \text{ 时}$$

$$P_{(\omega_0+\Omega)} = P_{(\omega_0-\Omega)} = \frac{1}{4} m_a^2 P_{0T} = \frac{1}{4} \times 0.7^2 \times 1000 = 122.5(W)$$

$$P_0 = P_{0T} + P_{(\omega_0+\Omega)} + P_{(\omega_0-\Omega)} = 1000 + 122.5 + 122.5 = 1245(W)$$

$$9-9 \text{解: } f = f_0 + f_1 + f_2 + f_3 + f_4 = 5 + 20 + 200 + 1780 + 8000 = 10005(kHz)$$

9-10解:  $i_1 = b_0 + b_1(v + v_\Omega) + b_2(v + v_\Omega)$   
 $i_2 = b_0 + b_1(v - v_\Omega) + b_2(v - v_\Omega)$   
 $v_0 = (i_1 - i_2)R = R[2b_1v_\Omega + 4b_2v$   
 $= 2b_1RV_\Omega \cos \Omega t + 3b_3RV_0^2V$   
 $+ 2b_2RV_0V_\Omega \cos(\omega_0 + \Omega)t$   
 $+ 1.5b_3RV_0^2V_\Omega \cos(2\omega_0 + \Omega)$   
 $+ 0.5b_3RV_0^3 \cos 3\Omega t$   
 输出端的频率分量:  $\Omega, 3\Omega,$



9-12解:  $m_1 = \sqrt{2\left(\frac{P_0}{P_{0r}} - 1\right)} = \sqrt{2 \times \left(\frac{1}{2}\right)}$   
 $P'_0 = P_0 + \frac{1}{2}m_2^2P_{0r} = 10.125 + \frac{1}{2}$   
 9-13(1)  $v_A(t) = v_\Omega(t) = V_\Omega \cos \Omega t$   
 $v_B(t) = v(t)$   
 (2)若  $D_1D_2$  开路, 则  $v_A(t) = v_B(t)$   
 $v_{AB} = 0$   
 (3)若  $D_1D_2$  短路, 则  $v_A(t) = v_\Omega(t)$   
 $v_B = 0$       $v_{AB}(t) = V_\Omega \cos t$

9-18解:  $R_\Omega = R_1 + \frac{R_2r_{i2}}{R_2 + r_{i2}} = 510 + \frac{4700 \times 1000}{4700 + 1000} = 1335(\Omega)$   
 $\theta = \sqrt[3]{\frac{3\pi R_d}{R}} = \sqrt[3]{\frac{3 \times 3.14 \times 100}{510 + 4700}} = 0.57$   
 $K_d = \cos \theta = 0.87$   
 $V_\Omega = K_d m_a V_{im} = 0.87 \times 0.3 \times 0.5 = 0.13$   
 $P_\Omega = \frac{V_\Omega^2}{2R_\Omega} = \frac{0.13^2}{2 \times 1335} = 6.33(\mu W)$   
 $P_\omega = \frac{V_{im}^2}{2R_{id}} = \frac{V_{im}^2 K_d}{R} = \frac{0.5^2 \times 0.87}{510 + 4700} = 41.7(\mu W)$   
 $A_p = \frac{P_\Omega}{P_\omega} = \frac{6.33}{41.7} = 0.152$



$$9-19 \text{解: (1) 中间位置 } \frac{R_{\Omega}}{R} = \frac{R_1 + R_2/2 + \frac{R_2/2 \cdot r_{i2}}{R_2/2 + r_{i2}}}{R_1 + R_2} = \frac{510 + 2350 + \frac{2350 \times 1000}{2350 + 1000}}{510 + 4700} = 0.55$$

$$(2) \text{最高端 } \frac{R_{\Omega}}{R} = \frac{R_1 + \frac{R_2 r_{i2}}{R_2 + r_{i2}}}{R_1 + R_2} = \frac{510 + \frac{4700 \times 1000}{4700 + 1000}}{510 + 4700} = 0.26$$

$\therefore R_2$ 的触点在中间位置会产生负峰切割失真，而在最高端不会。

$$9-20 \text{解: } R = R_1 + R_2 = (5 \sim 10) \text{k}\Omega \quad R_1 = \left(\frac{1}{5} \sim \frac{1}{10}\right) R_2 \quad \text{取 } R_2 = 6 \text{k}\Omega \quad R_1 = 1.5 \text{k}\Omega$$

$$R_{\Omega} = R_1 + \frac{R_2 r_{i2}}{R_2 + r_{i2}} = 1.5 + \frac{6 \times 2}{6 + 2} = 3 (\text{k}\Omega) \quad m_a < \frac{R_{\Omega}}{R} = \frac{3}{9} = \frac{1}{3} \quad \text{取 } m_a = 0.3$$

$$C < \frac{\sqrt{1 - m_a^2}}{m_a R_{\Omega_{\max}}} = \frac{\sqrt{1 - 0.3^2}}{0.3 \times 9000 \times 2 \times 3.14 \times 3000} = 0.018 (\mu\text{F}) \quad \text{取 } C_1 = C_2 = 0.01 \mu\text{F}$$

$$C_e \gg \frac{1}{\Omega_{\min} r_{i2}} = \frac{1}{2 \times 3.14 \times 300 \times 2000} = 0.26 (\mu\text{F}) \quad \text{取 } C_e = 20 \mu\text{F}$$

$$\theta = \sqrt[3]{\frac{3\pi R_d}{R}} = \sqrt[3]{\frac{3 \times 3.14 \times 100}{6000 + 1500}} = 0.5$$

$$K_d = \cos \theta = 0.9$$

$$R_{id} = \frac{R}{2K_d} = \frac{9000}{2 \times 0.9} = 5 (\text{k}\Omega) \text{ 能满足要求}$$

$$9-2 \text{解: } G_p = \frac{\omega_0 C}{Q} = \frac{2 \times 3.14 \times 465 \times 10^3 \times 200 \times 10^{-12}}{100} = 5.84 (\mu\text{S})$$

$$Q_L = \frac{f_0}{2\Delta f_{0.7}} = \frac{465}{20} = 235$$

$$P_{34} = \sqrt{\frac{\frac{Q_0}{Q_L} G_p - \beta_{2A}^2 g_{oe} - G_p}{g_{id}}} = \sqrt{\frac{\left(\frac{100}{235} \times 5.84 - 0.3^2 \times 100 - 5.84\right) \times 10^6}{\frac{2}{4700}}} = 0.153$$

9-24解:(1) $v_1 = mV_1 \cos \Omega t \cos \omega_1 t$

$$i = kmV_1 \cos \Omega t \cos \omega_1 t V_0 \cos(\omega_0 t + \varphi)$$

$$= \frac{1}{4} kmV_1 V_0 \{ \cos[(\omega_1 + \omega_0 + \Omega)t + \varphi] + \cos[(\omega_1 - \omega_0 + \Omega)t - \varphi] \\ + \cos[(\omega_1 + \omega_0 - \Omega)t + \varphi] + \cos[(\omega_1 - \omega_0 - \Omega)t - \varphi] \}$$

$$\text{当 } \omega_0 = \omega_1 \text{ 时, } v_s = \frac{1}{4} kmR_L V_1 V_0 [ \cos(\Omega t - \varphi) + \cos(\Omega t + \varphi) ] = \frac{1}{2} kmR_L V_1 V_0 \cos \varphi \cos \Omega t$$

无失真,  $\varphi$  只影响输出幅度。

$$\text{当 } \omega_0 \neq \omega_1 \text{ 时, } v_s = \frac{1}{2} kmR_L V_1 V_0 \cos[(\omega_1 - \omega_0)t - \varphi] \cos \Omega t$$

有失真。

$$(2) v_1 = \frac{1}{2} mV_1 \cos(\omega_1 + \Omega)t$$

$$i = \frac{1}{2} kmV_1 \cos(\omega_1 + \Omega)t V_0 \cos(\omega_0 t + \varphi)$$

$$= \frac{1}{4} kmV_1 V_0 \{ \cos[(\omega_1 + \omega_0 + \Omega)t + \varphi] + \cos[(\omega_1 - \omega_0 + \Omega)t - \varphi] \}$$

$$v_s = \frac{1}{4} kmR_L V_1 V_0 \cos[(\omega_1 - \omega_0 + \Omega)t - \varphi]$$

当  $\omega_0 = \omega_1$  时,  $\varphi$  只产生相移; 当  $\omega_0 \neq \omega_1$  时, 有失真。