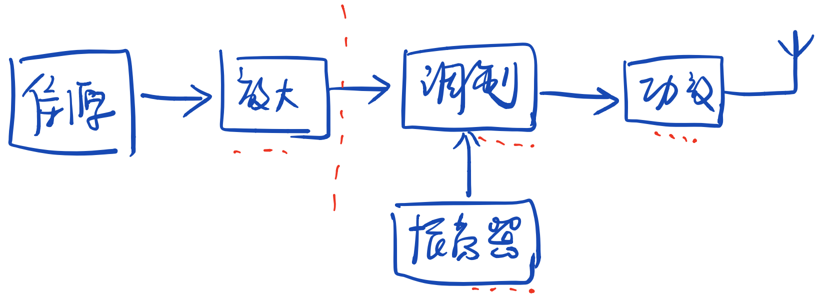
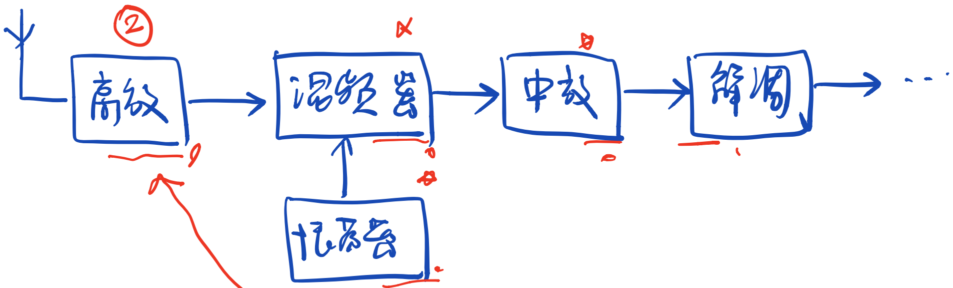
第二章 高频小信号放大器

收发信机：



接收机：



模块：{ R, L, C
K 辛

[2.1 选频网络 (R, L, C) [2-3次]
2.2 小信号谐振放大器 2次

2.1 选频网络.

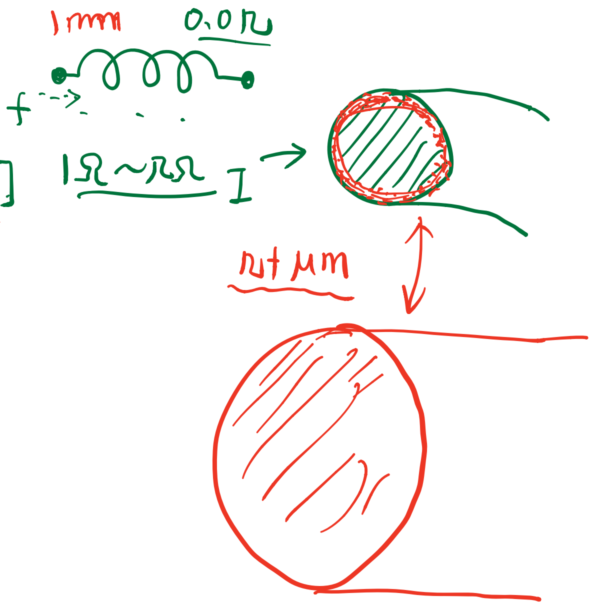
2.1.1 LC谐振回路 (并联谐振回路, 串联谐振回路)

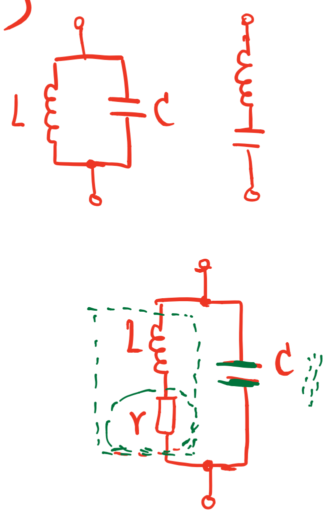
① 物理特性.

直流电阻：

[趋肤效应] 1Ω~几Ω I

交流电阻：

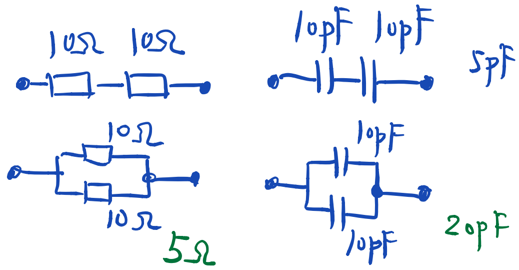


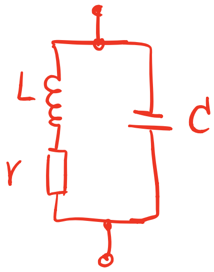


② 阻抗计算 (R, L, C)

回顾(电路, 模电)

串联:



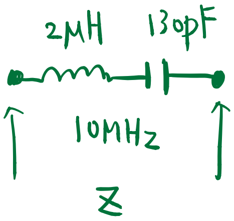


$$\begin{cases} R: & \Omega \\ L: & X_L = j\omega L \quad \underset{10^{-6}}{\mu H},\ \underset{10^{-9}}{nH} \\ C: & X_C = \dfrac{1}{j\omega C} \quad \underset{10^{-6}}{\mu F},\ \underset{10^{-12}}{pF} \end{cases}$$

✓ L: 10MHz, 2μH, $X_L = j\omega L = j\times 6.24\times 10^7 \times 2\times 10^{-6} \approx j125\Omega$

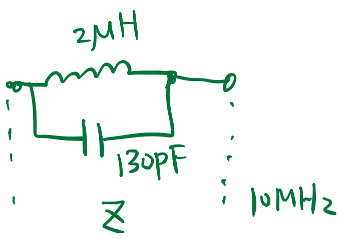
✓ C: 10MHz, 130pF (10^{-12}), $X_C = \dfrac{1}{j\omega L} = -j\dfrac{1}{6.24\times 10^7 \times 1.3\times 10^{-10}} = -j\dfrac{1000}{6.24\times 1.3} \approx -j125\Omega$

eg1:



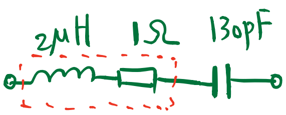
$$Z = j\omega L + \frac{1}{j\omega C} = 0.$$

eg2:



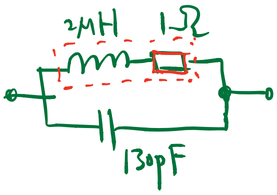
$$Z = \frac{j\omega L \cdot \frac{1}{j\omega C}}{j\omega L + \frac{1}{j\omega C}} = \frac{L/C}{j(\omega L - \frac{1}{\omega C})} = \infty$$

eg3:



10MHz. $Z = 1\Omega$

eg4:



10MHz.

$$Z = \frac{(r+j\omega L)\frac{1}{j\omega C}}{(r+j\omega L)+\frac{1}{j\omega C}} \overset{r \ll \omega L}{\approx} \frac{j\omega L \cdot \frac{1}{j\omega C}}{r + j(\omega L - \frac{1}{\omega C})}$$

$$= \frac{L/C}{r} = \frac{\frac{2\times 10^{-6}}{1.3\times 10^{-10}}}{1} = \frac{2}{1.3}\times 10^4$$

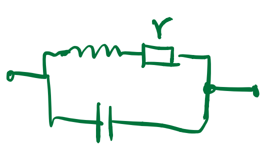
$\approx 15.4\,K\Omega$

$\rho = \sqrt{\dfrac{L}{C}}$

$$\boxed{Z = \frac{\rho^2}{r} = R_p}$$

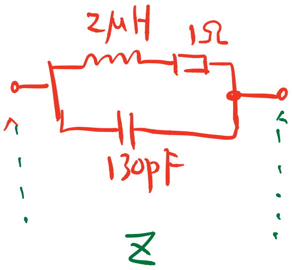
并联谐振回路 谐振时等效阻抗.

问题:



r 越小, R_p (大, 小)

谐振频率：



$$Z \approx \frac{L/C}{r + j\left(\omega L - \frac{1}{\omega C}\right)}$$

$$\omega L = \frac{1}{\omega C}$$

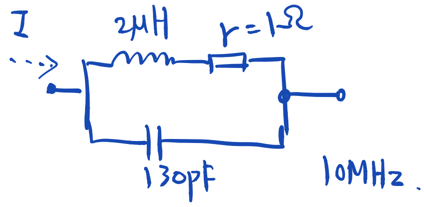
$$\omega_0^2 = \frac{1}{LC}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{6.24 \times \sqrt{2\times10^{-6} \times 1.3\times10^{-10}}}$$

$$= \frac{10^8}{6.28 \times \sqrt{2.6}} \approx 10\,MHz$$

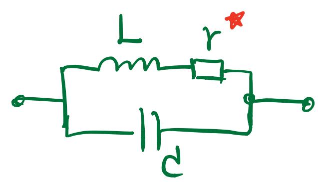
③ 品质因数 Q，理想电感，电容。



$$\boxed{Q = \frac{\omega_0 L}{r} = \frac{1}{\omega_0 C} \cdot \frac{1}{r}}$$

$$|X_L| = \omega_0 L \approx 125\,\Omega, \quad Q = 125$$

$$Q = \frac{\omega_0 L}{r} = \frac{1}{\sqrt{LC}} \cdot \frac{L}{r} = \sqrt{\frac{L}{C}}/r = \rho/r$$



① $\boxed{Q = \rho/r}$

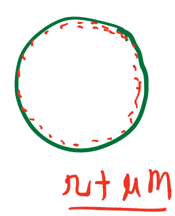
$$\boxed{R_p = \frac{L/C}{r} = \rho^2/r}$$

③ $\boxed{R_p = \frac{\rho^2}{r} = Q\rho}$

$$\rho = \sqrt{\frac{L}{C}} = \sqrt{\frac{2\times10^{-6}}{1.3\times10^{-10}}}$$

$$= \sqrt{\frac{2}{1.3}} \times 100 \approx 124.$$

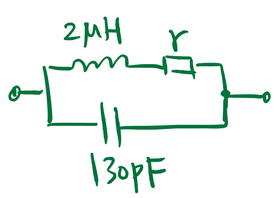
$$\rho = \sqrt{\frac{L}{C}}$$



$Q \approx 125.$

$R_p = Q\cdot\rho \approx 15.4\,k\Omega.$

eg:



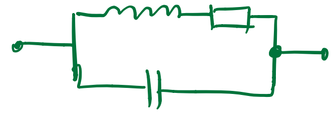
$L = 2\mu H$, $C = 130pF$, $Q \approx 125$，求 r, R_p ?

$\boxed{\rho = \sqrt{\frac{L}{C}}}$ $R_p = Q\rho$. $Q = \frac{\rho}{r} \Rightarrow r = \frac{\rho}{Q}$

r, R_p 与 Q 什么关系？

$$\boxed{R_p = Q\rho = Q\cdot Q\cdot r = Q^2\cdot r}$$

④ 谐振回路（幅频特性，相频特性）ω_0附近.



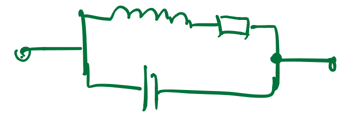
$$Z = \frac{L/C}{r + j\left(\omega L - \frac{1}{\omega C}\right)} = \frac{\frac{L}{Cr}}{1 + j\left(\omega L - \frac{1}{\omega C}\right)/r} = \frac{R_p}{1 + j\left(\omega L - \frac{1}{\omega C}\right)/r}$$

$$\left(\omega L - \frac{1}{\omega C}\right)/r = \frac{\omega_0 L}{r}\left[\frac{\omega}{\omega_0} - \frac{1}{\omega_0 L}\cdot\frac{1}{\omega C}\right] \overset{\frac{1}{LC}=\omega_0^2}{=\!=\!=} Q\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)$$

$$= Q\frac{\omega^2 - \omega_0^2}{\omega_0 \omega} = Q\frac{(\omega+\omega_0)(\omega-\omega_0)}{\omega_0 \omega} \overset{\omega\to\omega_0}{\approx} Q\frac{2\omega_0\cdot\Delta\omega}{\omega_0^2}$$

$$= Q\frac{2\Delta\omega}{\omega_0}$$

$$\boxed{Z = \frac{R_p}{1 + jQ\frac{2\Delta\omega}{\omega_0}}}$$



$$\begin{cases} |Z| = \dfrac{R_p}{\sqrt{1+\left(Q\cdot\frac{2\Delta\omega}{\omega_0}\right)^2}} \\ \phi = -\arctan\left(Q\dfrac{2\Delta\omega}{\omega_0}\right) \end{cases}$$

$\Delta\omega = 0$. $|Z| = R_p$