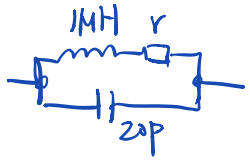
第四课 高频小信号放大器.

1. 作业.



, $Q=100$, f_0, R_p, $BW_{0.7}$

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

① $\omega L=\frac{1}{\omega C} \Rightarrow \omega_0=\frac{1}{\sqrt{LC}}$, $f_0=\frac{1}{2\pi\sqrt{LC}}=\frac{1}{6.28\times\sqrt{10^{-6}\times 20\times10^{-12}}}\approx 35.6MHz$

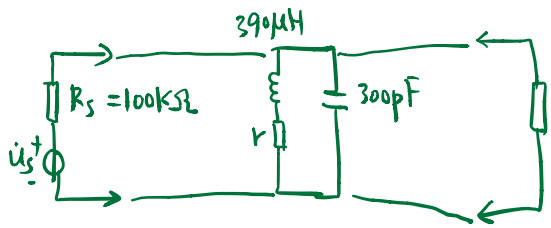
② $Z=\frac{L/C}{r}=\frac{\rho^2}{r}=R_p=Q\rho=100\times\sqrt{\frac{10^{-6}}{20\times10^{-12}}}\approx 22.4K\Omega$

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

③ $Q=\frac{\omega_0 L}{r}=\frac{1}{\sqrt{LC}}\cdot\frac{L}{r}=\sqrt{\frac{L}{C}}/r=\frac{\rho}{r}$

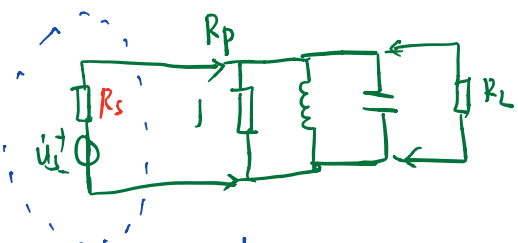
④ $BW_{0.7}=\frac{f_0}{Q}=\frac{35.6\times10^6}{100}=35.6\times10^4Hz=356KHz$.

2.



$Q_0=100$, 求 f_0, R_p, $BW_{0.7}$

$Q_0=\frac{\omega_0 L}{r}$



$Q_0=\frac{R_p}{\omega_0 L}$, $Q_e=\frac{R_e}{\omega_0 L}$ $\quad \frac{Q_e}{Q_0}=\frac{R_e}{R_p}$

$f_0=\frac{1}{2\pi\sqrt{LC}}=\frac{1}{6.28\times\sqrt{390\times10^{-6}\times300\times10^{-12}}}\approx 465KHz$

$100K\Omega//100K\Omega$

$R_p=Q\rho=100\times\sqrt{\frac{390\times10^{-6}}{300\times10^{-12}}}\approx 114K\Omega$

$Q_e=\frac{R_e}{R_p}\cdot Q_0$, $R_e=R_S//R_p//R_2=100K\Omega//114K\Omega//200K\Omega\approx 42K\Omega$

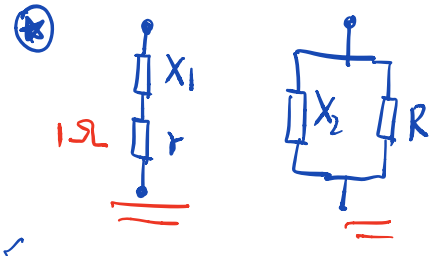
$50K\Omega$

$=\frac{42\times10^3}{114\times10^3}\cdot 100\approx 36.8$

$BW_{0.7}=\frac{f_0}{Q_e}=\frac{465\times10^3}{36.8}\approx 12.6KHz$.

电压谐振曲线：$\left|\frac{\dot{U}_0}{\dot{U}_p}\right| = \frac{1}{\sqrt{1+\left(Q\frac{2\Delta f}{f_0}\right)^2}} = \frac{1}{\sqrt{2}}$，$BW_{0.7} \cong 2\Delta f = \frac{f_0}{Q}$

$= \frac{1}{10}$　　$BW_{0.1} \approx \frac{f_0}{Q}\cdot 10$



$Q = 100$

$$\begin{cases} Z_1 = r + jX_1 \\ Z_2 = \dfrac{jRX_2}{R+jX_2} = \dfrac{jRX_2(R-jX_2)}{(R+jX_2)(R-jX_2)} = \dfrac{RX_2^2}{R^2+X_2^2} + j\dfrac{R^2X_2}{R^2+X_2^2} \end{cases}$$

$$\begin{cases} r = \dfrac{RX_2^2}{R^2+X_2^2} = \dfrac{R}{Q^2+1} \\ X_1 = \dfrac{R^2X_2}{R^2+X_2^2} = \dfrac{X_2}{1+1/Q^2} \end{cases}$$

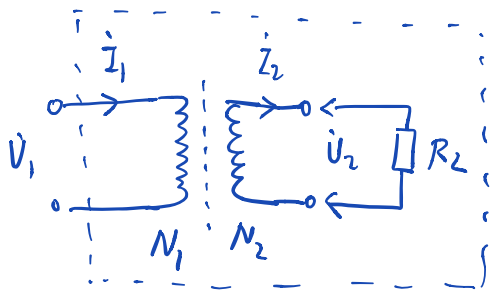
$$Q = \frac{|X_1|}{r} = \frac{R}{|X_2|}$$

$$R = r(1+Q^2)$$

$$X_2 = X_1(1+1/Q^2)$$

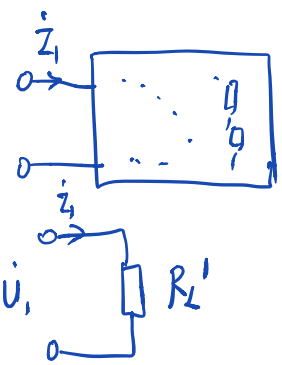
阻抗变换：

1° 变压器阻抗变换（理想）



$$\frac{\dot{U}_1}{\dot{U}_2} = \frac{N_1}{N_2} = n$$

$$\frac{\dot{U}_2^2}{R_L} = \frac{\dot{U}_1^2}{R_L'} \qquad \frac{\dot{U}_1^2}{\dot{U}_2^2} = \frac{R_L'}{R_L} = \left(\frac{N_1}{N_2}\right)^2 = n^2$$

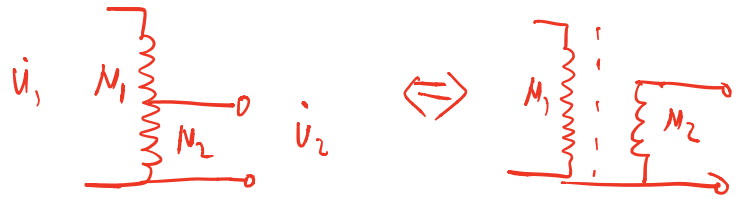


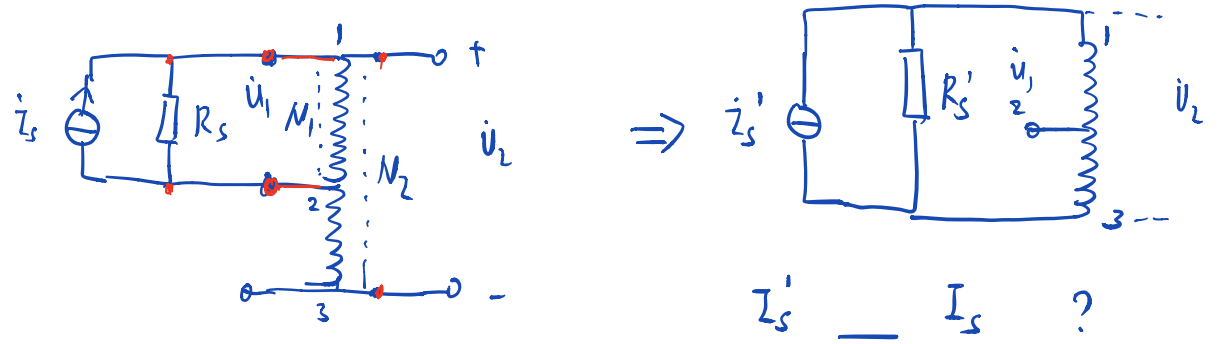
$$R_L' = \left(\frac{N_1}{N_2}\right)^2 \cdot R_L$$

$N_1 > N_2$，$n > 1$．　$R_L' \gtrless R_L$

例：$R_L = 1k\Omega$．　$N_1 = 10$，$N_2 = 2$．　$R_L' = ?$　$\left(\frac{N_1}{N_2}\right)^2 \cdot R_L = 25k\Omega$

2.





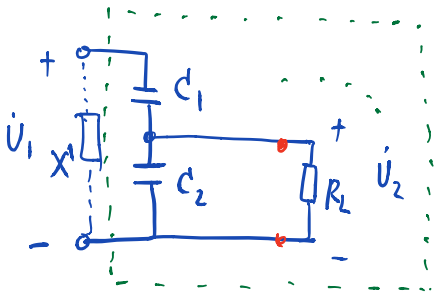
$I_S' \_\_ I_S$?

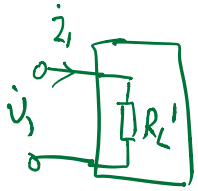
$R_S' \_\_ R_S$ ★

$$\frac{\dot{I}_S' = \dfrac{\dot{U}_2}{R_S'}}{I_S = \dfrac{\dot{U}_1}{R_S}} = \frac{\dot{U}_2}{\dot{U}_1}\cdot\frac{R_S}{R_S'} = \frac{\dot{U}_2}{\dot{U}_1}\cdot\left(\frac{\dot{U}_1}{\dot{U}_2}\right)^2 = \frac{\dot{U}_1}{\dot{U}_2}$$

$$\boxed{\frac{I_S'}{I_S} = \frac{\dot{U}_1}{\dot{U}_2} = \frac{N_1}{N_2}}$$

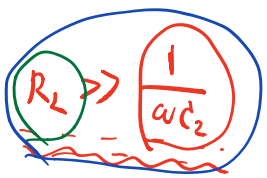
2° 电容分压阻抗变换：



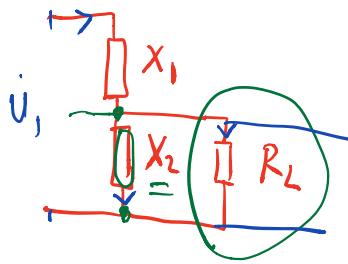


$$\frac{\dot{U}_2^2}{R_L} = \frac{U_1^2}{R_L'}, \quad R_L' = \left(\frac{U_1}{U_2}\right)^2\cdot R_L$$

$$\frac{\dot{U}_2}{\dot{U}_1} = \frac{\dfrac{1}{\omega C_2}}{\dfrac{1}{\omega C_1}}$$



$R_L' \geq R_L$

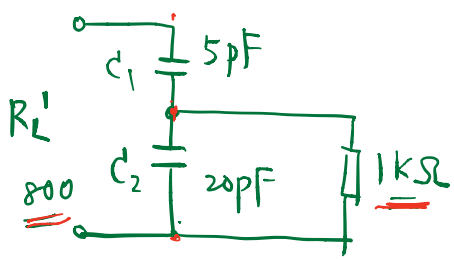


$$= \frac{C_1}{C_2} \quad \text{——} \quad \frac{\dfrac{C_1C_2}{C_1+C_2}}{C_2} = \frac{C_1}{C_1+C_2}$$

$$\boxed{\frac{\dot{U}_2}{\dot{U}_1} = \frac{C_1}{C_1+C_2}}$$

$$R_L' = \left(\frac{C_1+C_2}{C_1}\right)^2\cdot R_L$$

eg:



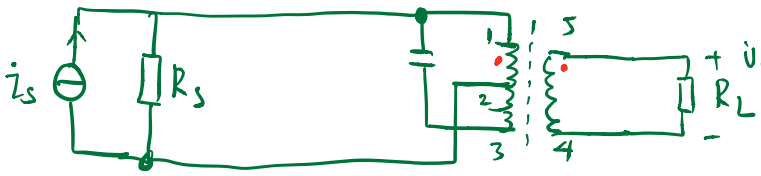
$$R_L' = \left(\frac{25}{5}\right)^2\cdot 1k\Omega = 25k\Omega.$$???

$f = 100MHz$.

$$\left|\frac{1}{\omega C_2}\right| = \frac{1}{6.28\times10^8\times20\times10^{-12}} \approx 80\Omega.$$

$f = 10MHz$. $\left|\frac{1}{\omega C_2}\right| = 800\Omega$

练习

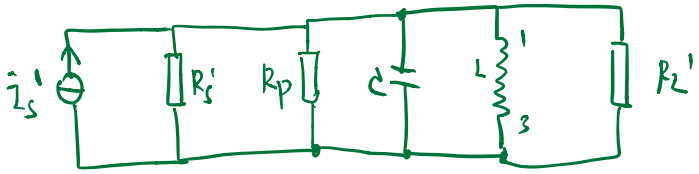


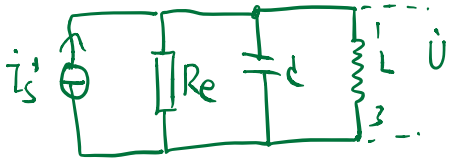
$n_{12}=10$, $n_{23}=40$, $n_{45}=5$

$L_{13}=8.4\mu H$, $Q_0=100$, $C=51pF$

$R_S=10K\Omega$, $I_S=1mA$, $R_L=2.5K\Omega$

求. Q_e, $BW_{0.7}$, $|\dot{U}_o|$.





R_e, $\dot{I}_S'$ $R_e = R_S' // R_p // R_L'$

① $R_L' = \left(\frac{n_{13}}{n_{45}}\right)^2 \cdot R_L = 250K\Omega$

② $R_S' = \left(\frac{n_{13}}{n_{12}}\right)^2 \cdot R_S = 250K\Omega$

③ $|\dot{I}_S'| = \frac{n_{12}}{n_{13}} \cdot |\dot{I}_S| = 0.2mA$.

③ $R_p = \frac{L}{Cr} = Q_p = 100 \times \sqrt{\frac{8.4\times10^{-6}}{51\times10^{-12}}} \approx 40.6K\Omega$

$R_e = 250K\Omega // 250K\Omega // 40.6K\Omega \approx 30.6K\Omega$.

$U_o' = I_S' \cdot R_e = 0.2\times10^{-3} \times 30.6\times10^3 = 6.1V$.

$U_o = \frac{n_{45}}{n_{13}} \cdot U_o' \approx 0.61V$.