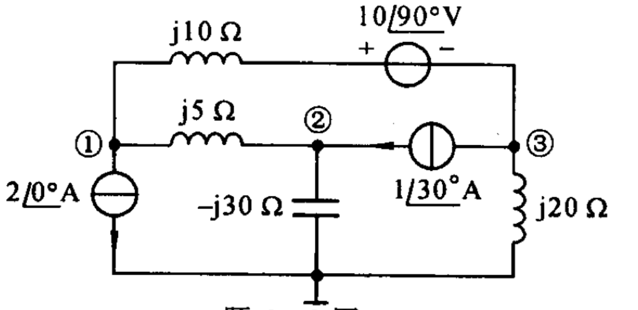
韩昊辰

-23，6-25，6-31。

6－2　试求题 6－2 图所示电路中各节点对地的电压相量。



题 6－2 图

$$\left(\frac{1}{5j}+\frac{1}{10j}\right)\dot U_1-\frac{1}{5j}\dot U_2-\frac{1}{10j}\dot U_3=-2\angle 0^\circ+\frac{10\angle 90^\circ}{10j}$$

$$-\frac{1}{5j}\dot U_1+\left(-\frac{1}{j30}+\frac{1}{5j}\right)\dot U_2=1\angle 30^\circ$$

$$-\frac{1}{j10}\dot U_1+\left(\frac{1}{j10}+\frac{1}{j20}\right)\dot U_3=\frac{-10\angle 90^\circ}{10j}-1\angle 30^\circ$$

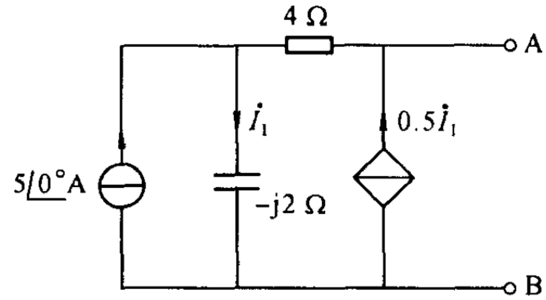
$$\dot U_1=\frac{\begin{vmatrix}-1\angle 0^\circ & \frac{j}{5} & \frac{j}{10}\\ 1\angle 30^\circ & \frac{1}{6j} & 0\\ -\sqrt3\angle 15^\circ & 0 & \frac{3}{j20}\end{vmatrix}}{\begin{vmatrix}\frac{3}{10j} & \frac{j}{5} & \frac{j}{10}\\ \frac{j}{5} & \frac{1}{6j} & 0\\ \frac{j}{10} & 0 & \frac{3}{j20}\end{vmatrix}}$$

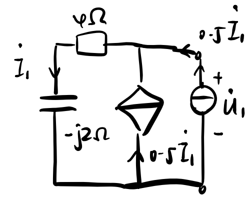
$$=\frac{0.6788+0.01613j}{\frac{89j}{600}}=\frac{0.679\angle 1.361^\circ}{0.89\angle 90^\circ}=185\angle 77.5^\circ$$

$$\dot U_2=226.5\angle 78.5^\circ$$

$$\dot U_3=112\angle 74.5^\circ$$

6－9　试求题 6－9 图所示电路对 AB 端口的诺顿等效电路。





$$\dot I_1\cdot 4+\dot I_1(-j2)-\dot U_1=0$$

$$\dot U_1=4\dot I_1-2j\dot I_1=4.472\angle -26.6^\circ\,\dot I_1$$

$$X_{eq}=\frac{\dot U_1}{0.5\dot I_1}=8.944\angle -26.6^\circ\ \Omega$$

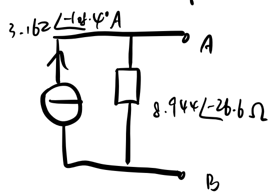
KCL:

$$0.5\dot I_1+5\angle 0^\circ=\dot I_1\Rightarrow \dot I_1=10\angle 0^\circ\ \mathrm{A}$$

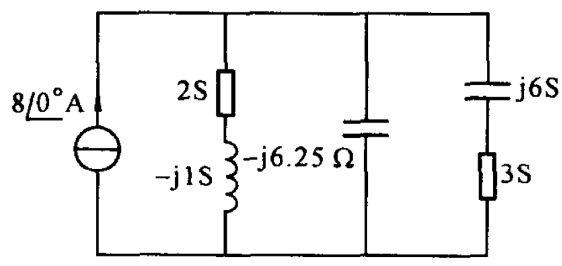
KVL: $\dot U_{BA}+0.5\dot I_1\cdot 4-\dot I_1(-j2)=0$

$$\dot U_{BA}=-2\sqrt2\angle 45^\circ\cdot 10\angle 0^\circ=28.28\angle -135^\circ$$

$$\dot I'=\frac{\dot U_{BA}}{X_{eq}}=3.162\angle -108.4^\circ\ \mathrm{A}$$



6－14　求题 6－14 图所示电路吸收的总复功率 $\tilde S$ 和功率因数。



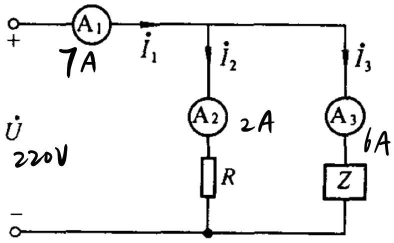
$$\dot Y_{总}=\frac{18j}{6j+3}+\frac{1}{-j6.25}+\frac{-2j}{2-j1}=2.8+0.56j\ S$$

$$\dot Z_{总}=\frac{1}{\dot Y_{总}}=\frac{2.8-0.56j}{8.1536}=0.35\angle -11.31^\circ\ \Omega$$

$$\tan\varphi=\frac{-0.56}{2.8}=-0.2,\quad \lambda=\cos\varphi=\frac{5\sqrt{26}}{26}=0.98$$

$\tilde{S} = \dot{U}\dot{I} = \dot{I}^2 \cdot Z_{总} = 64\angle 0^\circ \cdot 0.35\angle -11.31^\circ = 22.4\angle -11.31^\circ$ W

6－15　用三只电流表测定一电容性负载的功率的电路如题 6－15 图所示，设其中表 A_1 的读数为 7A，表 A_2 的读数为 2A，表 A_3 的读数为 6A，电源电压有效值为 220V，试画出电流、电压的相量图，并计算负载 Z 所吸收的平均功率及其功率因数。



取 $\dot{I}_1 = 7\angle 0^\circ$ A

$\dot{I}_1 = \dot{I}_2 + \dot{I}_3$

$\dot{I}_2 \cdot R = \dot{I}_3 \cdot Z = \dot{U}$

如图：$\cos\varphi = \frac{36+49-4}{2\times 42} = 0.964$

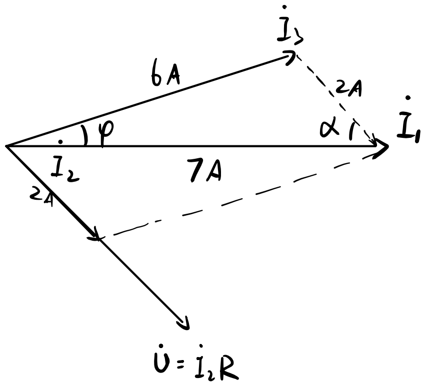
$\cos\alpha = \frac{4+49-36}{28} = 0.607$

$\dot{I}_3 = 6\angle 15.42^\circ$ A

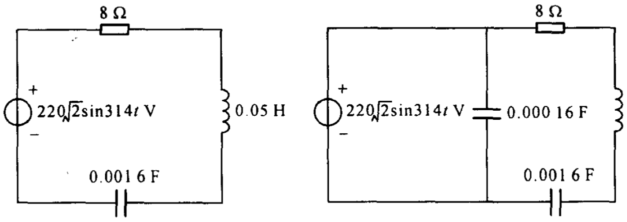
$\dot{U} = 220\angle -52.63^\circ$ V

$\lambda = \cos(\alpha+\varphi) = \cos(68.05^\circ) = 0.3738$

$P = UI\cdot\lambda = 493.4$ W



6－16　已知一 RLC 串联电路如题 6－16(a)图所示，试求该电路吸收的有功功率及其功率因数。又若在此 RLC 串联电路两端并联一个电容，如题 6－16(b)图所示，求电源发出的有功功率及其功率因数。



(a)　(b)

$\omega = 314$

$Z_a = R + \frac{1}{j\omega C} + j\omega L$

$= 8 + \left(\frac{-625}{314} + 15.7\right)j$

$= 8 + 13.71j$

$= 15.87\angle 59.7^\circ\ \Omega$

$\lambda_a = \cos\varphi_a = 0.504$

$P_a = \left|\frac{\dot{U}^2}{Z_a}\right| \cdot \lambda_a = 1537$ W

$Z_b = Z_a \parallel C$

$= \frac{15.87\angle 59.7^\circ \cdot \frac{1}{j\cdot 314\cdot 0.00016}}{8+13.71j + \frac{1}{j\cdot 314\cdot 0.00016}}$

$= \frac{315.9\angle -30.3^\circ}{8-6.2j}$

$= \frac{315.9\angle -30.3^\circ}{10.12\angle -37.78^\circ}$

$= 31.215\angle 7.48^\circ\ \Omega$

$\therefore \lambda_b = 0.9915$

$P_{(b)} = \left|\frac{U^2}{Z_b}\right| \lambda_b = 1537.4$ W

6－13　一个电感性负载在工频正弦电压源激励下吸收的平均功率为 1 000W，其端电压有效值为 220V，通过该负载的电流为 5A，试确定串联等效参数 $R_串$、$L_串$ 和并联等效参数 $R_并$、$L_并$。

$P = UI\cos\varphi = 1000$ W ③

$U = 220$ V ① $I = 5$ A ②

①、② 代入③：$\cos\varphi = 0.909$，$\varphi = 24.63^\circ$

$|Z| = \frac{U}{I} = 44\ \Omega$

$\therefore Z = 44\angle 24.63^\circ = 40 + j18.3\ \Omega$

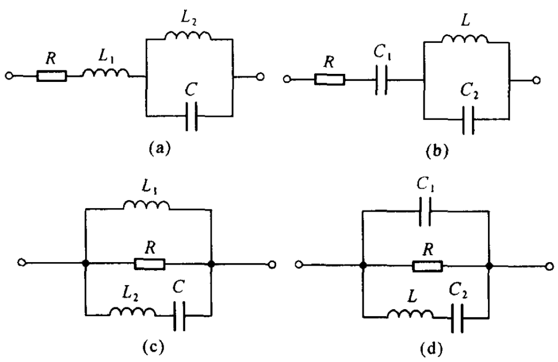
$\therefore R_串 = 40\ \Omega$　$L_串 = \frac{18.3}{\omega} = \frac{18.3}{314} = 58.3$ mH

$Y = \frac{1}{Z} = \frac{40 - j18.3}{1934.89} = 0.0207 - 9.46\times 10^{-3} j$ S

$\therefore R_并 = \frac{1}{0.0207}\ \Omega = 48.31\ \Omega$

$L_并 = \frac{\frac{1}{9.46\times 10^{-3}}}{314} = 0.3367$ H

6-20 试求题 6-20 图所示各电路的谐振角频率的表达式。



a).

$$Z = R + j\omega L_1 + \frac{j\omega L_2 \cdot \frac{1}{j\omega C}}{j\omega L_2 + \frac{1}{j\omega C}}$$

$$= R + j\omega L_1 \frac{-j}{\omega L_2 - \frac{1}{\omega C}} \cdot \frac{L_2}{C}$$

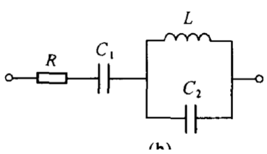
$$= R + j\left(\omega L_1 + \frac{\omega L_2}{1 - \omega^2 L_2 C}\right)$$

$1°$ $\omega L_1 - \frac{\frac{L_2}{C}}{\omega L_2 - \frac{1}{\omega C}} = 0 \Rightarrow \omega = \sqrt{\frac{1}{C}\left(\frac{1}{L_1} + \frac{1}{L_2}\right)}$ rad/s

$2°$ $\omega' L_2 - \frac{1}{\omega' C} = 0 \Rightarrow \omega' = \sqrt{L_2 C}$ rad/s

b).

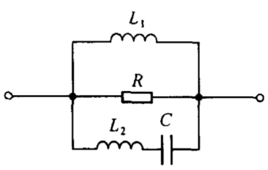
$$Z = R + \frac{1}{j\omega C_1} + \frac{\frac{L}{C_2}}{j\omega L + \frac{1}{j\omega C_2}}$$



$$= R + \left(\frac{-1}{\omega C_1} + \frac{\omega L}{1 - \omega^2 L C_2}\right) j$$

$1°$ $\frac{1}{\omega C_1} = \frac{\omega L}{1 - \omega^2 L C_2} \Rightarrow \omega = \sqrt{\frac{1}{L(C_1 + C_2)}}$ rad/s

$2°$ $1 - \omega'^2 L C_2 = 0 \Rightarrow \omega' = \frac{1}{\sqrt{L C_2}}$ rad/s



c).

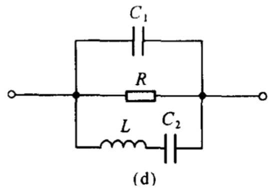
$$Y = \frac{1}{R} + \frac{1}{j\omega L_1} + \frac{1}{j\omega L_2 + \frac{1}{j\omega C}}$$

$$= \frac{1}{R} - \frac{j}{\omega L_1} + \frac{-j}{\omega L_2 - \frac{1}{\omega C}}$$

$$= \frac{1}{R} - j\left(\frac{1}{\omega L_1} + \frac{1}{\omega L_2 - \frac{1}{\omega C}}\right) S$$

$1°$ $\frac{1}{\omega L_1} = \frac{1}{\frac{1}{\omega C} - \omega L_2} \Rightarrow \omega = \sqrt{\frac{1}{C(L_1 + L_2)}}$ rad/s

$2°$ $\omega' L_2 = \frac{1}{\omega' C} \Rightarrow \omega' = \sqrt{\frac{1}{L_2 C}}$ rad/s



$$Y = \frac{1}{R} + j\omega C_1 + \frac{1}{j\left(\omega L - \frac{1}{\omega C_2}\right)}$$

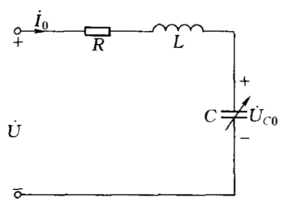
$$= \frac{1}{R} + j\left(\omega C_1 - \frac{1}{\omega L - \frac{1}{\omega C_2}}\right)$$

$1°$ $\omega C_1 = \frac{1}{\omega L - \frac{1}{\omega C_2}}$

$\Rightarrow \omega = \sqrt{\frac{C_2 + C_1}{C_2 C_1 L}}$ rad/s

$2°$ $\omega' = \sqrt{\frac{1}{L C_2}}$ rad/s

6-22 在题 6-22 图所示电路中，电源电压 $U = 10$V，角频率 $\omega = 3\ 000$rad/s。调节电容 C 使电路达到谐振，谐振电流 $I_0 = 100$mA，谐振电容电压 $U_{C_0} = 200$V。试求 R、L、C 之值及回路的品质因数 Q。



题 6-22 图

$U_{C0} + U_{L0} = 0$

$\therefore$ $U_R = U = 10V$

$R = \frac{U_R}{I_0} = \frac{10}{0.1} = 100\Omega$

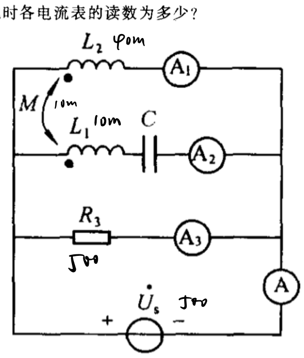
$\frac{U_{C0}}{I_0} = \frac{1}{\omega C} = \frac{200}{0.1} = 2000$

$C = \frac{1}{2000 \times 3000} = 1.67 \times 10^{-7}$ F

$\frac{U_{L0}}{I_0} = \omega L \Rightarrow L = 0.67$ H

$Q = \frac{U_{C0}}{U} = 20$

6-23 在题 6-23 图中，$L_1 = 10$mH，$L_2 = 40$mH，$|M| = 10$mH，$R_3 = 500\Omega$，$U_s = 500$V，$\omega = 10^4$rad/s，C 的大小恰好使电路发生并联谐振，问此时各电流表的读数为多少？



$I_1 \omega L_2 + I_2 \omega |M| = U_s$

$I_2 = -I_1$

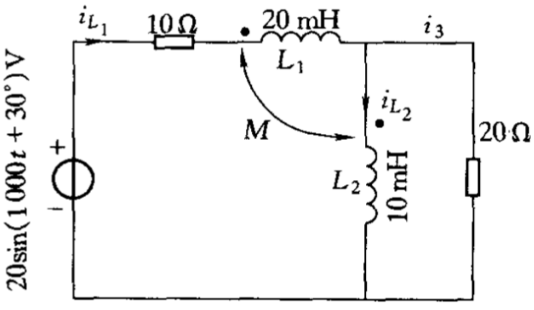
$\therefore$ $I_1 = \frac{500}{10^4 \times (40 - 10) \times 10^{-3}} = 1.67A$

$|I_2| = |I_1| = 1.67A$

$I_3 = \frac{U_s}{R} = 1A.$

$I = I_1 + I_2 + I_3 = I_1 - I_1 + I_3 = 1A$

6－25　试求题 6－25 图所示含有耦合电感元件的电路中的电流 i_{L_1} 和 i_{L_2}。设 $|M|=10\text{mH}$。



题 6－25 图

KVL: $\dot{i}_{L1}(10+j1000\times20\times10^{-3}) + \dot{i}_{L2}\cdot j1000\cdot10\cdot10^{-3}$

$+ \dot{i}_{L2}\, j1000\cdot10\cdot10^{-3} + \dot{i}_{L1}\, j1000\cdot10\cdot10^{-3} = 10\sqrt{2}\angle 30^\circ$

$\Rightarrow \dot{i}_{L1}\cdot(10+30j) + \dot{i}_{L2}(20j) = 10\sqrt{2}\angle 30^\circ$

$\Rightarrow \dot{i}_{L1}(1+3j) + \dot{i}_{L2}(2j) = \sqrt{2}\angle 30^\circ$ ①

KVL: $\dot{i}_{L1}(10+20j) + \dot{i}_{L2}\cdot 10j + (\dot{i}_{L2} - \dot{i}_{L1})\cdot 20 = 10\sqrt{2}\angle 30^\circ$

$\dot{i}_{L1}(-10+20j) + \dot{i}_{L2}(20+10j) = 10\sqrt{2}\angle 30^\circ$

$\dot{i}_{L1}(-1+2j) + \dot{i}_{L2}(2+j) = \sqrt{2}\angle 30^\circ$ ②

①、②: $$\dot{i}_{L1} = \frac{\begin{vmatrix} \frac{\sqrt6}{2}+\frac{\sqrt2}{2}j & 2j \\ \frac{\sqrt6}{2}+\frac{\sqrt2}{2}j & 2+j \end{vmatrix}}{\begin{vmatrix} 1+3j & 2j \\ -1+2j & 2+j \end{vmatrix}} = \frac{\sqrt6-\frac{\sqrt2}{2}+(\sqrt2+\frac{\sqrt6}{2})j+\sqrt6 j-\sqrt2}{-1+7j-2j-4}$$

$$= \frac{0.328+2.639j}{-5+5j} = \frac{7.07\angle 82.92^\circ}{\sqrt{50}\angle 135^\circ}$$

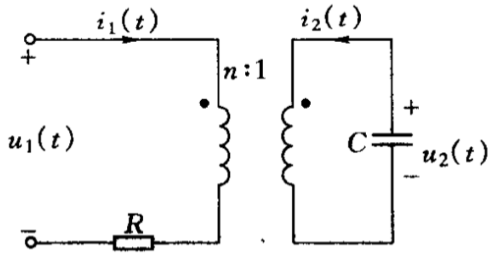
$$= 0.287\angle -28.25^\circ\ A$$

同理 $\dot{i}_{L2} = 0.287\angle -81.35^\circ\ A$

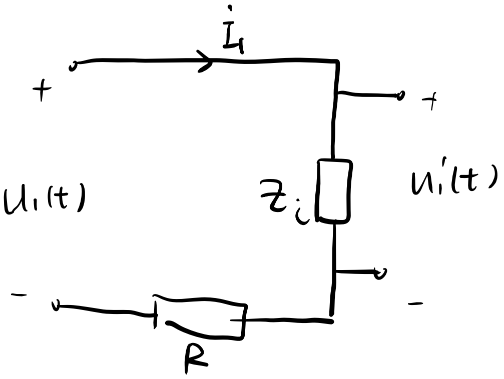
$i_1(t) = 0.287\sin(1000t - 28.25^\circ)\ A$

$i_2(t) = 0.287\sin(1000t - 81.35^\circ)\ A$

6-31 在题 6-31 图所示电路中，理想变量器的变比 $n=10$，$u_1(t)=100\sin(314t+30^\circ)$V，$R=10\Omega$，$C=0.1$F，求电路在正弦稳态下的电流 $i_1(t)$、$i_2(t)$和电压 $u_2(t)$。



输入端等效电路：



$$Z_i = n^2 Z_L$$

$$= 100 \times \frac{1}{314 \times 0.1j}$$

$$= -3.185j\ \Omega$$

$$= 3.185\angle -90^\circ$$

$$\dot{U}_{1m} = 100\angle 30^\circ\ V$$

$$\dot{I}_{1m} = \frac{\dot{U}_{1m}}{Z_i + R} = \frac{100\angle 30^\circ}{10 - 3.185j}$$

$$= \frac{100\angle 30^\circ}{10.495\angle -17.67^\circ} = 9.529\angle 47.67^\circ\ A$$

$$i_1(t) = 9.529\sin(314t + 47.67^\circ)$$

$$\dot{U}'_{1m} = \dot{I}_1 \cdot Z_i = 30.35\angle -42.33^\circ\ V$$

$$\dot{U}_{2m} = \frac{1}{n}\dot{U}'_{1m} = 3.035\angle -42.33^\circ\ V$$

$$u_2(t) = 3.035\sin(314t - 42.33^\circ)\ V$$

$$i_2(t) = -n i_1(t) = -95.29\sin(314t + 47.67^\circ)\ A$$