2004年硕士研究生《电路》试题答案

一、解：$\dot U_S = 200\sqrt{2}\angle 0^\circ$ V，$j\omega L = j10^3\times 1 = j1^k$，$\frac{1}{j\omega C} = -j\frac{1}{10^3\times 10^{-6}} = -j1^k$.

(1) $\dot I = \dfrac{\dot U_S}{-j\frac{1}{\omega C}+(R+j\omega L)//(R+\frac{1}{j\omega C})} = \dfrac{200\sqrt{2}\angle 0^\circ}{-j1^k+(1^k+j1^k)//(1^k-j1^k)} = \dfrac{200\sqrt{2}\angle 0^\circ}{1^k-j1^k}$

$= 0.2\angle 45^\circ$ A

$i(t) = 0.2\sqrt{2}\cos(10^3t+45^\circ)$ A

$I = 0.2$ A

(2) $\dot U_{cd} = (R+j\omega L)//(R+\frac{1}{j\omega C})\,\dot I = 1^k\times 0.2\angle 45^\circ = 200\angle 45^\circ$ V

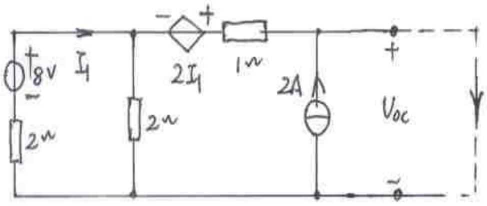
$\dot U_{ab} = \dfrac{j\omega L}{R+j\omega L}\dot U_{cd} - \dfrac{\frac{1}{j\omega C}}{R+\frac{1}{j\omega C}}\dot U_{cd} = \left(\dfrac{j1^k}{1^k+j1^k} - \dfrac{-j1^k}{1^k-j1^k}\right)\dot U_{cd} = j\dot U_{cd}$

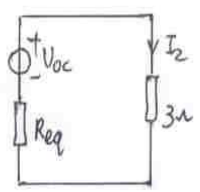
$= 200\angle 135^\circ$ V

(3) $P = Re[\dot U_S \dot I^*] = Re[200\sqrt{2}\angle 0^\circ \times 0.2\angle -45^\circ] = Re[40\sqrt{2}\angle -45^\circ]$

$= 40$ W

二、解：利用戴维南定理，将左边电路等效





$V_{oc} = (2+2)\times\frac{8}{2+2}+2+2\times(-1)+2 = 10$ V

$I_{sc} = 10$ A

$R_{eq} = \dfrac{V_{oc}}{I_{sc}} = \dfrac{10^V}{10^A} = 1\Omega$（也可利用"加压"法直接计算）

$I_2 = \dfrac{V_{oc}}{R_{eq}+3} = \dfrac{10}{1+3} = 2.5$ A

三、解：结点电位方程为（选结点4为参考结点）

$$\begin{cases} U_{n1} = 4I_1 \\ (\frac{1}{2}+\frac{1}{2}+1)U_{n2} - \frac{1}{2}U_{n1} - U_{n3} = -2+6 \\ U_{n3} = 6 \end{cases}$$

又 $I_1 = U_{n2}/2$

∴ $U_{n1} = 20$ V，$U_{n2} = 10$ V，$U_{n3} = 6$ V

受控源流出的电流为 $\dfrac{U_{n1}-U_{n3}+10}{4}+\dfrac{U_{n1}-U_{n2}}{2}-2 = 9$ A

受控源的功率为 $P = U_{n1}\times(-11) = -180$ W（发出功率）

四、解：根据叠加定理、互易定理求解.

(1) 根据叠加定理：$U_3 = k_1 U_{s_1} + k_2 U_{s_2}$

U_{s_1} 单独作用，$U_{s_2}=0$ 时，$U_3' = U_1' - U_2' = 8-4 = 4^V$，$U_3' = k_1 U_{s_1}$

$\therefore 4 = k_1 \times 16 \qquad k_1 = \frac{1}{4}$

(2) 根据互易定理：U_{s_1} 接于 U_{s_2} 处，U_{s_1} 代入以短接时，可得

$U_3'' = U_1'' - U_2'' = 4-8 = -4^V$，$U_3'' = k_2 U_{s_1}$，$k_2 = -\frac{1}{4}$

(3) 由此可得：$U_3 = \frac{1}{4} U_{s_1} - \frac{1}{4} U_{s_2}$ （U_{s_1}, U_{s_2} 共同作用时）

且 $U_3 = -8^V$ 时，$-8 = \frac{1}{4}\times 16 - \frac{1}{4}\times U_{s_2}$

$\therefore U_{s_2} = 48^V$

五、解：设并联部分电位为 $\dot{U}_1 = U_1\angle 0^\circ$ V，则 $\dot{U} = 220\angle\varphi$.

$U_1 = \sqrt{R^2+(\omega L)^2} \times I_1 = \sqrt{10^2+10^2} \times 10\sqrt{2} = 200^V$.

$\therefore \dot{U}_1 = 200\angle 0^\circ$ V，

$\dot{I}_1 = 10\sqrt{2}\angle -45^\circ$ A，$\dot{I}_2 = 10\angle 90^\circ$ A

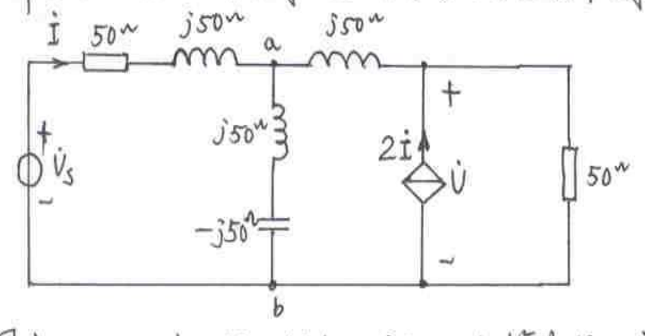
$\dot{I} = \dot{I}_1 + \dot{I}_2 = 10\sqrt{2}\angle -45^\circ + 10\angle 90^\circ = 10\angle 0^\circ$ A

由 $R_1\dot{I} + \dot{U}_1 = \dot{U} \Rightarrow 10R_1\angle 0^\circ + 200\angle 0^\circ = 220\angle\varphi \Rightarrow \varphi = 0^\circ$

$R_1 = (220-200)/10 = 2\Omega$

$P = \mathrm{Re}[\dot{U}\dot{I}^*] = \mathrm{Re}[220\angle 0^\circ \times 10\angle 0^\circ] = 2200$ W

六、解：原电路去耦等效的相量模型如下图所示



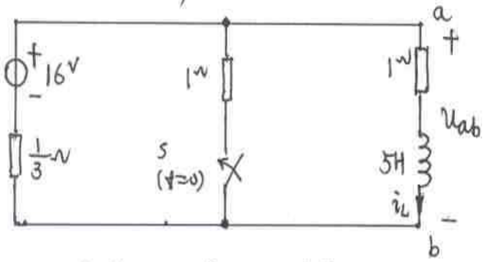
$\dot{U}_s = 100\angle 0^\circ$ V

图中，a、b两点等效阻抗为零，两点等电位，$U_{ab}=0$.

$\dot{I} = \frac{100\angle 0^\circ}{50+j50} = \sqrt{2}\angle -45^\circ$ A

$\dot{U} = (50 /\!/ j50)\times 2\dot{I} = \frac{50j}{1+j}\times 2\times\sqrt{2}\angle -45^\circ = 100\angle 0^\circ$ V

七、解：先将左边部分等效得到下图.



$$i_L(0_-)=\frac{16}{\frac{1}{3}+1}=12\ A$$

再利用三要素法求解.

① $u_{ab}(0_+)=\dfrac{16\times3-12}{3+1}=9\ V$

② $u_{ab}(\infty)=\dfrac{16\times3}{3+1+1}=9.6\ V$

③ $\tau=L/R_{eq}=5/(5/4)=4\ s$, 其中 $R_{eq}=1+1//(\frac{1}{3})=\frac{5}{4}\ \Omega$

$$u_{ab}(t)=9.6+(9-9.6)e^{-\frac{t}{4}}=\underline{9.6-0.6e^{-\frac{t}{4}}}\ V \qquad t\geq0$$

八、解：首先求出a, b左边电路的戴维南等效电路

$$\dot U_{oc(ab)}=\frac{-\dot I_s+\dfrac{2\dot I_s}{R_1+j\omega L}}{\dfrac{1}{R_1+j\omega L}+\dfrac{1}{R_2+\frac{1}{j\omega C}}}=\frac{-\dot I_s+\frac{2}{1+j}\dot I_s}{\frac{1}{1+j}+\frac{1}{1-j}}=-\dot I_s+(1-j)\dot I_s=-j\dot I_s$$

$$\dot I_{sc(ab)}=\frac{2\dot I_s}{R_1+j\omega L}-\dot I_s=\frac{2}{1+j}\dot I_s-\dot I_s=-j\dot I_s$$

$$Z_{eq}=\frac{\dot U_{oc(ab)}}{\dot I_{sc(ab)}}=1\ \Omega$$

(1) 当 $Z_L'=Z_{eq}^*=1\ \Omega$ 时，即 $\underline{Z_L=\frac{1}{4}Z_L'=\frac{1}{4}\ \Omega}$ 时，Z_L可从电路获得最大功率.

(2) 最大传输功率 $P_{max}=\dfrac{U_{oc}^2}{4Re[Z_{eq}]}=\dfrac{I_s^2}{4\times1}=\dfrac{20^2}{4}=\underline{100}\ W$

九、解：(1) 电流表的读数

$$I=\frac{380/\sqrt{3}}{|Z|}=\frac{220}{|16+j12|}=\underline{11\ A}$$

(2) 三相负载吸收的总功率

$$P=3\times I^2\times Re[Z]=3\times11^2\times16=\underline{5808}\ W$$

(3) 并联Δ型电容网络的功率因数

$$Q=3\times I^2\times Im[Z]-3\times\omega C\times380^2=3\times11^2\times12-3\times314\times30\times10^{-6}\times380^2$$

$$=4356-4080.744\doteq275\ Var$$

$$\varphi=tg^{-1}\frac{Q}{P}=tg^{-1}\frac{275}{5808}=tg^{-1}0.0474=2°43'$$

$$\cos\varphi\doteq1$$

十.解：∵ $\begin{bmatrix} u_1 \\ i_1 \end{bmatrix} = \begin{bmatrix} 2.5 & 3 \\ 0.5 & 2 \end{bmatrix} \begin{bmatrix} u_2 \\ -i_2 \end{bmatrix}$ ∴ $\begin{cases} u_1 = 2.5u_2 - 3i_2 \\ i_1 = 0.5u_2 - 2i_2 \end{cases}$

① $u_s(t)$中10^V直流作用时，L_1, L_2短接，$u_2^{(0)} = 0$

$\begin{cases} u_1^{(0)} = -3i_2^{(0)} \\ i_1^{(0)} = -2i_2^{(0)} \end{cases}$ 又 $u_1^{(0)} = 10 - i_1^{(0)}$

∴ $i_2^{(0)} = -2^A$

② $u_s(t)$中$100\sqrt{2}\cos\omega t$作用时，C与L_2的并联导纳为

$Y = j\frac{1}{6} + \frac{1}{j6} = 0$ 即C与L_2发生并联谐振

$\dot{I}_2^{(1)} = 0$

③ $u_s(t)$中$10\sqrt{2}\cos 3\omega t$作用时，$\dot{U}_S^{(3)} = 10\angle 0^{\circ} \, V$

∵ 2.2′右侧等效阻抗为 $Z = j3\times 0.75 + (j3\times 6)//(-j6/2) = 0$

∴ 2.2′右侧发生串联谐振 $\dot{U}_2^{(3)} = 0$

故有 $\begin{cases} \dot{U}_1^{(3)} = -3\dot{I}_2^{(3)} \\ \dot{I}_1^{(3)} = -2\dot{I}_2^{(3)} \end{cases}$ 又 $\dot{U}_1^{(3)} = \dot{U}_S^{(3)} - \dot{I}_1^{(3)}$

∴ $\dot{I}_2^{(3)} = 2\angle 180^{\circ} \, A = -2^A$

$i_2(t) = -2 + 2\sqrt{2}\cos(3\omega t + 180^{\circ}) \, A$

$I_2 = \sqrt{(-2)^2 + 2^2} = 2\sqrt{2} \, A$