2006年硕士研究生《电路》试题参考答案

一、解：结点电位方程为

$$\begin{cases}\frac{1}{5}u_{n1}-\frac{1}{5}u_{n2}=5-I\\ u_{n2}=5I_1\\ -\frac{1}{6}u_{n2}+(\frac{1}{6}+\frac{1}{8})u_{n3}=I\end{cases}\qquad 补充：\begin{cases}u_{n1}-u_{n3}=4\\ I_1=\frac{1}{8}u_{n3}\end{cases}$$

解得：$u_{n1}=20^V$，$u_{n2}=10^V$，$u_{n3}=16^V$，$I=3^A$

$P=4I=12^W$ （吸收）

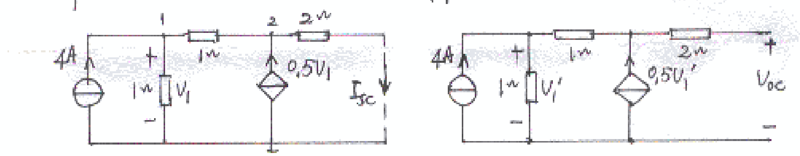
二、解：根据叠加定理，应有

$I=k_1I_S+k_2U_S=2I_S-0.1U_S$

其中：$\begin{cases}1=k_1+10k_2\\ 4.5=2k_1-5k_2\end{cases}\Rightarrow k_1=2,\ k_2=-0.1$

当 $U_S=15^V$，$I_S=2.5^A$ 时，$I=2\times2.5-0.1\times15=3.5^A$

三、解：S1：先求R_L左边电路的戴维南等效电路



① $I_{sc}=\frac{1}{2}U_2=2A$，∵ $\begin{cases}2U_1-U_2=4\\ -U_1+1.5U_2=0.5U_1\end{cases}$ （结点方程） $\Rightarrow U_1=U_2=4^V$

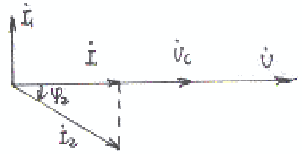
② $U_{oc}=0.5U_1'+1.0U_1'=12^V$，∵ $U_1'=4+0.5U_1'$ $\Rightarrow U_1'=8$

③ $R_{eq}=U_{oc}/I_{sc}=6^\Omega$

S2：$R_L=R_{eq}=6^\Omega$时，R_L获得最大功率，

$$P_{max}=\frac{U_{oc}^2}{4R_{eq}}=\frac{12^2}{4\times6}=6^W$$

四、解：S1：因已知$\dot U$与$\dot I$同相，而$\dot U=R\dot I+\dot U_C$，因此可知，$\dot U_C$与$\dot I$、$\dot U$同相，可作出如右图所示相量图。



相应地：

$\dot U=220\angle0^\circ V$，$\dot U_C=U_C\angle0^\circ V$，$\dot I=I\angle0^\circ A$

$\dot I_1=10\angle90^\circ A$，$\dot I_2=20\angle\varphi_2\ A$

∴ $I_1 + I_2\sin\varphi_2 = 0$, ⇒ $\varphi_2 = -30°$, $I = I_2\cos 30° = 10\sqrt{3}$ A

S2: 因 Z_2 上消耗功率为 $P_2 = 2^{kW}$，故有

$$U_C = \frac{P_2}{I_2\cos(\varphi_2)} = \frac{2\times10^3}{20\times\cos30°} = 115.5^{V}$$

$$X_C = \frac{U_C}{I_1} = \frac{115.5}{10} = 11.55\ \Omega$$

$$Z_2 = \frac{\dot U_C}{\dot I_2} = \frac{115.5\angle0°}{20\angle-30°} = 5.77\angle30°\ \Omega = 5+j2.89\ \Omega$$

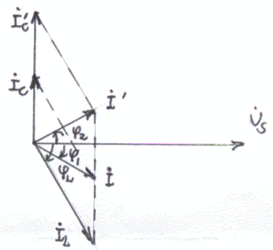
$$R = \frac{\dot U_R}{\dot I} = \frac{104.5\angle0°}{10\sqrt{3}} = 6.04\ \Omega$$（其中 $\dot U_R = \dot U - \dot U_C = 104.5\angle0°$ V）

五、解：S1：设 $\dot U_S = 100\angle0°$ V，根据已知条件，可得如下相量图。

相应地，

$\dot I_C = \frac{\dot U_S}{-jX_C} = 10\angle90°$ A，$\dot I_L = \frac{\dot U_S}{R_L+jX_L} = I_L\angle\varphi_L$ A

$\dot I = 10\angle\varphi_1$ A，$\dot I_C' = 20\angle90°$ A，$\dot I' = 1\angle\varphi_2$ A



满足上述条件时，可求出

$\varphi_L = -60°$，$\varphi_1 = -30°$，$\varphi_2 = 30°$

∵ $I\cos30° = I_L\cos60°$

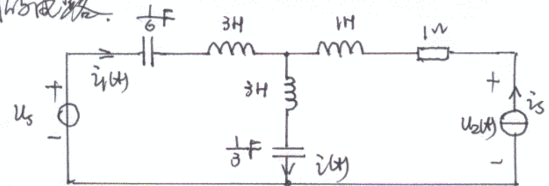
∴ $I_L = \sqrt{3}\,I = 10\sqrt{3}$ A

S2：$I_L = \frac{U_S}{\sqrt{R_L^2+X_L^2}}$ ⇒ $\sqrt{R_L^2+X_L^2} = \frac{10}{\sqrt{3}}$，又 $\frac{X_L}{R_L} = tg(-\varphi_L) = \sqrt{3}$

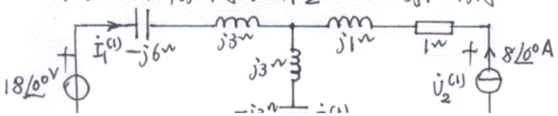
∴ $\sqrt{R_L^2+X_L^2} = 2R_L$ ⇒ $R_L = \frac{5}{\sqrt{3}}\ \Omega$，$X_L = 5\ \Omega$，

S3：$P = I_L^2\times R_L = (10\sqrt{3})^2\times\frac{5}{\sqrt{3}} = 500\sqrt{3} = 866$ W

六、解：先作出去耦等效电路，再分别计算基波作用和二次谐波作用的电路。



S1：基波作用，相量模型如下图。则有



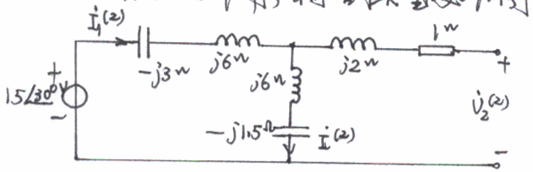
$$\dot I_1^{(1)} = \frac{18\angle0°}{-j6+j3} = 6\angle90°\ A$$

$$\dot I^{(1)} = \dot I_1^{(1)} + 8\angle0°$$

$\dot{U}_2^{(1)} = 8\angle 0^\circ \times (1+j1) = 8\sqrt{2}\angle 45^\circ$ V

$i^{(1)} = 10\sqrt{2}\cos(t+36.9^\circ)$ A

S2：二次谐波作用，相量模型如下图，则有



$$\dot{I}_1^{(2)} = \frac{15\angle 30^\circ}{-j3+j6+j6-j1.5} = 2\angle -60^\circ \text{ A}$$

$$\dot{I}^{(2)} = \dot{I}_1^{(2)} = 2\angle -60^\circ \text{ A}$$

$\dot{U}_2^{(2)} = 2\angle -60^\circ(j6-j1.5) = 9\angle 30^\circ$ V

$i^{(2)} = 2\sqrt{2}\cos(2t-60^\circ)$ A

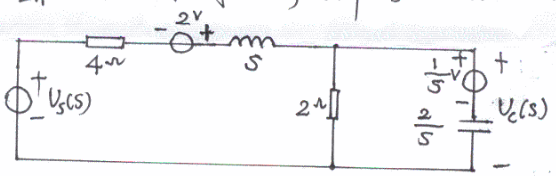
S3) 总电流 $i(t) = i^{(1)}+i^{(2)} = 10\sqrt{2}\cos(t+36.9^\circ)+2\sqrt{2}\cos(2t-60^\circ)$ A

S4) 电源发出的功率分别为

$P_{U_S} = 18\times 6\times\cos 90^\circ + 2\times 9\times\cos 90^\circ = 0$

$P_{I_S} = 8\sqrt{2}\times 8\times\cos 45^\circ = 64$ W

七、解：运算电路如下图所示，其中 $U_S(s) = L[2\varepsilon(t)] = \frac{2}{s}$ V



结点电位方程为

$$\left(\frac{1}{s+4}+\frac{1}{2}+\frac{s}{2}\right)U_C(s) = \frac{U_S(s)+2}{s+4} + \frac{\frac{1}{s}}{\frac{2}{s}}$$

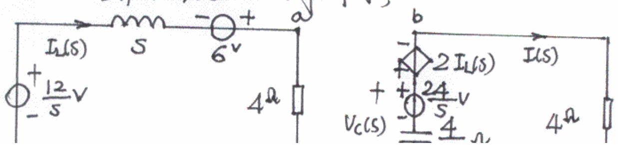
$$\therefore U_C(s) = \frac{\frac{4}{s}+s+8}{(s+2)(s+3)} = \frac{s^2+8s+4}{s(s+2)(s+3)}$$

$$= \frac{2}{3}\times\frac{1}{s} + 4\times\frac{1}{s+2} - \frac{11}{3}\times\frac{1}{s+3}$$

$$\therefore u_C(t) = \left(\frac{2}{3}+4e^{-2t}-\frac{11}{3}e^{-3t}\right)\varepsilon(t) \text{ V}$$

八、解：S1：$i_L(0_-) = \frac{12}{4/\!/4} = 6$ A，$u_C(0_-) = ri_L(0_-) + R_2\times\frac{i_L(0_-)}{2} = 4i_L(0_-) = 24$ V

S2：运算电路如下图所示，



S3: $\because (4+s)I_L(s)-6-\frac{12}{s}=0$

$\therefore I_L(s)=\frac{1}{4+s}(\frac{12}{s}+6)=\frac{6s+12}{s(s+4)}=\frac{3}{s}+\frac{3}{s+4}$

$i_L(t)=\mathcal{L}^{-1}[I_L(s)]=(3+3e^{-4t})\,\varepsilon(t)$ A

S4: $\because (4+\frac{4}{s})I(s)-\frac{24}{s}+2I_L(s)=0$, 且 $U_c(s)=\frac{24}{s}-\frac{4}{s}I(s)$

$\therefore U_c(s)=\frac{24}{s}-\frac{4}{s}\times\frac{s}{4(s+1)}(\frac{24}{s}-2I_L(s))=\frac{24}{s}-\frac{24}{s(s+1)}+\frac{2}{s}I_L(s)$

$=\frac{24}{s+1}+\frac{2(6s+12)}{s(s+1)(s+4)}=\frac{20}{s+1}+\frac{6}{s}-\frac{2}{s+4}$

$u_c(t)=\mathcal{L}^{-1}[U_c(s)]=(6+20e^{-t}-2e^{-4t})\varepsilon(t)$ V

S5: $\because U_{ab}(s)=4I_L(s)-U_c(s)+2I_L(s)=6I_L(s)-U_c(s)$

$\therefore u_{ab}(t)=\mathcal{L}^{-1}[U_{ab}(s)]=6i_L(t)-u_c(t)=18(1+e^{-4t})-6-20e^{-t}+2e^{-4t}$

$=(12-20e^{-t}+20e^{-4t})\,\varepsilon(t)$ V

九、解：由传输参数矩阵可得

$\begin{cases}U_1=2U_2-6I_2\\ I_1=0.5U_2-1.5I_2\end{cases}\Rightarrow\begin{cases}I_2=0\text{时},\ U_{oc}=U_2=\frac{1}{2}U_1=6\ \text{V}\\ U_2=0\text{时},\ I_{sc}=-I_2=\frac{1}{6}U_1=2\ \text{A}\end{cases}$

$\therefore R_{eq}=U_{oc}/I_{sc}=3\ \Omega$

故：1) 当 $R=R_{eq}=3\ \Omega$ 时，获得最大功率，$P_{max}=\frac{U_{oc}^2}{4R_{eq}}=\frac{6^2}{4\times3}=3$ W

2) U_s 的功率 $P_{U_s}=-U_1I_1=-12[0.5\times3-1.5\times(-1)]=-36$ W（发出）

十、解：S1：设负载端相电压 $\dot{U}_{A'N'}=220\angle0^\circ$ V，则有

$I_A=\frac{P}{\sqrt{3}U_{A'B'}\cos\varphi}=\frac{760\sqrt{3}}{\sqrt{3}\times380\times0.707}=2\sqrt{2}$ A， 且 $\varphi=45^\circ$.

$\therefore \dot{I}_A=2\sqrt{2}\angle-45^\circ$ A

S2：电源端相电压 $\dot{U}_A=Z_l\dot{I}_A+\dot{U}_{A'N'}=\sqrt{2}\angle45^\circ\cdot2\sqrt{2}\angle-45^\circ+220\angle0^\circ$

$=224\angle0^\circ$ V

电源端线电压 $\dot{U}_{AB}=\sqrt{3}\dot{U}_A\angle30^\circ=388\angle30^\circ$ V

S3：功率表的读数 $P=\mathrm{Re}[\dot{U}_{BC}\dot{I}_A^*]=\mathrm{Re}[\dot{U}_{AB}\angle-120^\circ\dot{I}_A^*]$

$=\mathrm{Re}[\sqrt{3}\dot{U}_A\angle-90^\circ\dot{I}_A^*]=\mathrm{Re}[\sqrt{3}\dot{U}_A\dot{I}_A^*\angle-90^\circ]$

$=\sqrt{3}U_AI_A\cos(45^\circ-90^\circ)=776$ W

S4：因功率表的读数可表示为 $P=\mathrm{Re}[\sqrt{3}\dot{U}_A\dot{I}_A^*\angle-90^\circ]$

$\therefore P=\sqrt{3}U_AI_A\cos(\varphi-90^\circ)=\sqrt{3}U_AI_A\sin\varphi$

$=U_{AB}I_A\sin\varphi$