浙江大学 2024 年研究生入学考试

初试试题解析

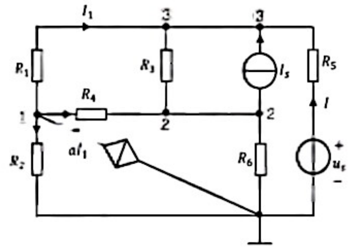
试题代号：840　　　　试题名称：电路原理

参考书：电路—邱关源

试题及答案获取方式：关注公棕号【梦马强哥电路课堂】，后台回复“24840”

一、【分析】考查电路方程。

电路如下图所示



由题意易得

$$I = 0$$

节点电压方程如下

$$\begin{cases}\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_4}\right)u_{n_1}-\dfrac{1}{R_4}u_{n_2}-\dfrac{1}{R_3}u_{n_3}=\alpha I_1\\ -\dfrac{1}{R_4}u_{n_1}+\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_6}\right)\dfrac{1}{R_4}u_{n_2}-\dfrac{1}{R_3}u_{n_3}=-I_s\\ u_{n_3}=u_s\end{cases}$$

附加方程

$$I_1=\frac{u_{n_1}-u_{n_3}}{R_1}$$

解得

$$\begin{cases} u_{n_1} = \dfrac{60}{7}V \\ u_{n_2} = \dfrac{24}{7}V \\ I_1 = -\dfrac{2}{7}A \end{cases}$$

对于①节点列KCL可得

$$\begin{cases} \dfrac{u_{n_1}}{R_2} + \dfrac{u_{n_1} - u_{n_2}}{R_6} - \alpha I_1 = 0 \\ I_1 = -\dfrac{2}{7}A \end{cases}$$

得

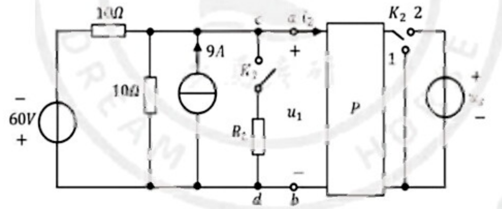
$$\alpha = -\frac{9}{2}A$$

$$P_{I_s} = (u_{n_1} - u_{n_2})I_s = \frac{60}{7} \times 1 = \frac{60}{7}W$$

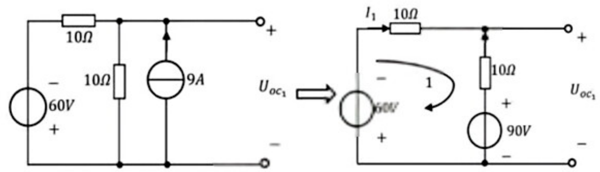
I_s发出$\frac{60}{7}W$功率。

二、【分析】考查戴维南定理。

(1)当开关k_1打开时，求cd左侧戴维南等效电路如下图所示



求U_{OC_1}电路如下图所示



对回路 1 列KVL可得

$$(10+10)I_1 + 90 + 60 = 0$$

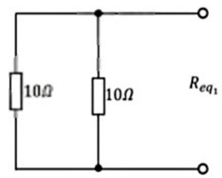
解得

$$I_1 = -7.5A$$

则

$$U_{OC_1} = 10I_1 + 90V = 15V$$

求R_{eq1}电路如下图所示



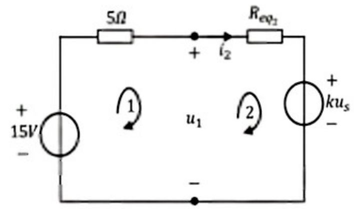
$$R_{eq_1} = \frac{10 \times 10}{10 + 10} = 5\Omega$$

求ab右侧戴维南等效电路。

设

$$u_1 = R_{eq_2}i_2 + ku_s$$

则整体电路等效如下图所示



当$u_s = 0$时，$u_1 = 10V$，则

$$\frac{R_{eq_2}}{5 + R_{eq_2}} \times 15 = 10$$

解得

$$R_{eq_2} = 10\Omega$$

当$u_s = 60V$时，$u_1 = 18V$。

对回路 1 列KVL可得

$$5i_2 + u_1 - 15 = 0$$

解得

$$i_2 = -0.6A$$

对回路 2 列KVL可得

$$i_2R_{eq_2} + 60k - u_1 = 0$$

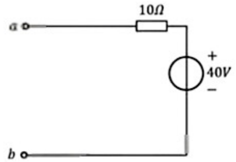
带入整理可得

$$-6+60k-18=0$$

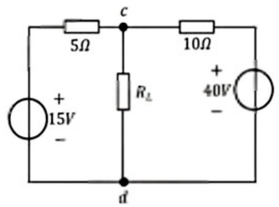
解得

$$k=0.4$$

故当$u_s=100V$时，ab右端戴维南等效电路如下图所示

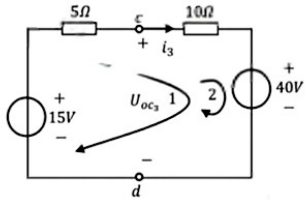


(2)当$u_s=100V$，开关k_2闭合时电路如下图所示



以R_L为感兴趣支路求戴维南电路。

求U_{OC_3}电路如下图所示



对回路 1 列KVL可得

$$(10+5)i_3+40-15=0$$

解得

$$i_3=-\frac{5}{3}A$$

对回路 2 列KVL可得

$$10i_3+40-U_{OC_3}=0$$

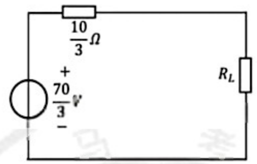
解得

$$U_{OC_3}=\frac{70}{3}V$$

R_{eq_3}易得

$$R_{eq_3}=5//10=\frac{10}{3}\Omega$$

故戴维南电路如下图所示



故当$R_L=\frac{10}{3}\Omega$时，　R_2取得大功率

$$R_{Lmax}=\frac{{U_{OC}}^2}{4R_L}=\frac{245}{6}W$$

三、【分析】考查矩阵方程。

(1)3、5、6 为树支，则 1、2、4、7 为连支

$$B_f=\begin{array}{c} \\ 1\\2\\4\\7\end{array}\begin{array}{c}\begin{matrix}1&2&3&4&5&6&7\end{matrix}\\ \begin{bmatrix}1&0&-1&0&-1&0&0\\0&1&-1&0&-1&0&0\\0&0&-1&1&0&-1&0\\0&0&0&-1&1&0&1\end{bmatrix}\end{array}$$

(2)

$$Z=\begin{array}{c} \\ 1\\2\\3\\4\\5\\6\\7\end{array}\begin{array}{c}\begin{matrix}1&2&3&4&5&6&7\end{matrix}\\ \begin{bmatrix}R_1&&&&&&\\&\frac{1}{j\omega C_2}&&&&\frac{\beta}{j\omega C_6}&\\&&j\omega L_3&j\omega M&&&\\&&j\omega M&j\omega L_4+R_4&&&\\&&&&R_5&&\\&&&&&\frac{1}{j\omega C_6}&\\&&&&&&R_7\end{bmatrix}\end{array}$$

(3)

$$\dot{U}_s=\left[\dot{U}_{s_1}\quad 0\quad 0\quad 0\quad 0\quad 0\quad U_{sT}\right]^T$$

(4)

$$\dot{I}_s = [0 \quad 0 \quad 0 \quad 0 \quad I_{s5} \quad 0 \quad 0]^T$$

(5)

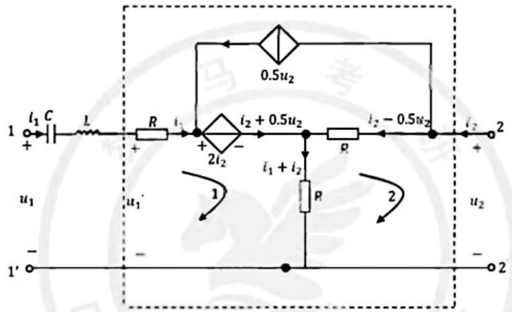
$$Z_1 = B_f \cdot Z \cdot B_f^{T}$$

(6)

$$B_f \cdot Z \cdot B_f^{T} \cdot \dot{I}_6 = -B_f \cdot Z \cdot I_s - B_f \dot{U}_s$$

四、【分析】考查二端口网络与复频域分析

(1)电路如下图所示



对回路 1 列KVL可得

$$2i_1 + 2i_2 + 2(i_1 + i_2) - u_1{}' = 0$$

对回路 2 列KVL可得

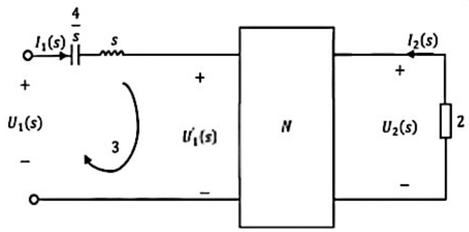
$$-2(i_2 - 0.5u_2) + u_2 - 2(i_1 + i_2) = 0$$

解得

$$\begin{cases} u_1{}' = 4i_1 + 4i_2 \\ u_2 = i_1 + 2i_2 \end{cases}$$

$$Z = \begin{bmatrix} 4 & 4 \\ 1 & 2 \end{bmatrix}$$

(2)运算电路如下图所示



由Z参数得

$$U_1^{'}(s)=4I_1(s)+4I_2(s)=4I_1(s)+4\times\frac{-U_2(s)}{2}$$

$$U_2(s)=I_1(s)+2I_2(s)=I_1(s)+2\times\frac{-U_2(s)}{2}$$

解得

$$\begin{cases}U_1^{'}(s)=4I_1(s)-2U_2(s)\\U_2(s)=I_1(s)-U_2(s)\end{cases}$$

对回路 3 列KVL可得

$$U_1(s)=\left(s+\frac{4}{s}\right)I_1(s)+U_1^{'}(s)=\left(s+\frac{4}{s}\right)I_1(s)+3I_1(s)=\left(s+\frac{4}{s}+3\right)I_1(s)$$

故

$$H(s)=\frac{U_2^{'}(s)}{U_1(s)}=\frac{\frac{1}{2}I_1(s)}{\left(s+\frac{4}{s}+3\right)I_1(s)}=\frac{\frac{1}{2}s}{s^2+3s+4}$$

(3)零点：当$\frac{1}{2}s=0\Rightarrow s=0$为零点

极点：当$s^2+3s+4=0\Rightarrow p_1=-\frac{3}{2}+j\frac{\sqrt{7}}{2}$，$p_2=-\frac{3}{2}-j\frac{\sqrt{7}}{2}$为极点。

五、【分析】考查均匀传输线

方法：从右向左求始端，从左向右求终端。

(1)

$$\gamma_1=\alpha+j\beta=\sqrt{2}\times10^{-3}\angle45^{\circ}=10^{-3}+j10^{-3}$$

$$\begin{cases}\lambda=V\cdot T=\dfrac{V}{f}\\V=\dfrac{\omega}{\beta}\end{cases}\Rightarrow\lambda=\frac{2\pi}{\beta}$$

$$U(x)=\dot{U}_2\cos\beta x+jZ_C\dot{I}_2\sin\beta x$$

$$I(x)=\dot I_2\cos\beta x+jZ_C\frac{\dot U_2}{Z_C}\sin\beta x$$

$$Z_{C_3}=\frac{U(x)}{I(x)}\overset{\dot I_2=0}{=}\frac{\dot U_2\cos\beta x}{j\frac{\dot U_2}{Z_C}\sin\beta x}=-jZ_C\cdot\frac{1}{tan\beta x}=-j100\sqrt{3}\cdot\frac{1}{tan\frac{2\pi}{\lambda}\cdot\frac{\lambda}{6}}=-j100\Omega$$

$$\xrightarrow{\text{分子分母除以}\cos\beta x}\frac{Z_2+jZ_C tan\beta x}{1+j\frac{Z_2}{Z_C}tan\beta x}$$

$$=\frac{100+j50+j50\sqrt{2}tan\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}}{1+j\frac{100+j50}{50\sqrt{2}}\cdot tan\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}}=\frac{\left(50\sqrt{2}\right)^2}{100+j50}=40-j20$$

$$Z_{bb'右}=Z_{C_2}//Z_{C_3}=(-j100)//(40-j20)=25-j25\Omega$$

(2)因为$Z_{bb'}=Z_{C_1}$发生阻抗匹配，则

$$\dot U_s=25\angle30°$$

$$\dot I=\frac{\dot U_s}{Z_1+Z_{C_1}}=\frac{25\angle30°}{25+25-j25}=\frac{\sqrt{5}}{5}\angle56.57°A$$

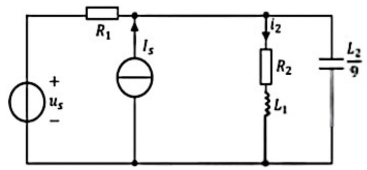
$$i(t)=\frac{\sqrt{10}}{5}sin(\omega t+56.57°)A$$

六、【分析】考查非正弦周期信号与二段口网络结合

(1)根据二端口回转器特性，电路右侧为电容

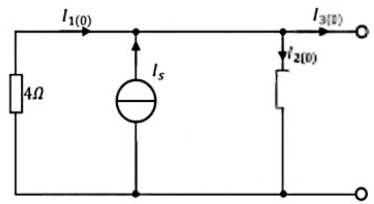
$$\frac{\dot U_3}{\dot I_3}=\frac{-3\dot I_4}{\frac{1}{3}\dot U_4}\xrightarrow{\dot U_4\text{与}\dot I_4\text{非关联}}9\frac{1}{j\omega L_2}=-j\frac{9}{\omega L_2}$$

电路等效如下图所示



$$P=I_1^2R_1+I_2^2R_2\Rightarrow175=25\times4+25R_2\Rightarrow R_2=3\Omega$$

(2)当直流源单独作用时，电路如下图所示



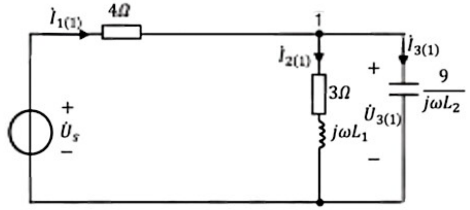
经分流公式得

$$I_{1(0)} = 3A; \ I_{2(0)} = 4A; \ I_{3(0)} = 0A$$

故

$$I_{1(1)} = \sqrt{I_1^2 - I_{1(0)}^2} = 4A; \ I_{2(1)} = \sqrt{I_2^2 - I_{2(0)}^2} = 3A; \ I_{3(1)} = \sqrt{I_3^2 - I_{3(0)}^2} = 5A$$

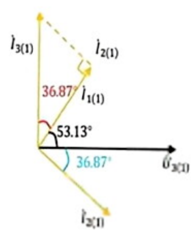
当交流单独作用时，电路如下图所示



设$\dot{U}_{3(1)} = \dot{U}_3\angle 0°$，对 1 节点列$KCL$可得

$$\dot{I}_{1(1)} = \dot{I}_{2(1)} + \dot{I}_{3(1)}$$

相量图如下图所示



根据几何分析得

$$\dot{I}_{1(1)} = 4\angle 53.13°; \ \dot{I}_{2(1)} = 3\angle -36.87°; \ \dot{I}_{3(1)} = 5\angle 90°$$

则

$$\tan\left(0°-(-36.87°)\right)=\frac{\omega L_1}{3}=\frac{3}{4}\Rightarrow\omega L_1=\frac{9}{4}\Omega\Rightarrow L_1=\frac{9}{4}mH$$

$$\dot{U}_{3(1)}=(R_2+j\omega L_1)\dot{I}_{2(1)}=\frac{45}{4}\angle 0°$$

则

$$\frac{\dot{U}_{3(1)}}{\dot{I}_{3(1)}}=\frac{9}{\omega L_2}\Rightarrow L_2=4mH$$

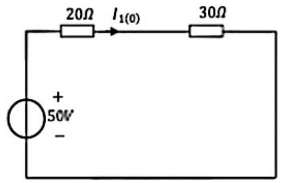
(3)对回路列KVL易得

$$\dot{U}_s=R_1\dot{I}_{1(1)}+\dot{U}_{3(1)}=4\times 4\angle 53.13°+\frac{45}{4}\angle 0°=24.47\angle 31.55°V$$

$$U_s=24.47V$$

七、【分析】考查非正弦周期信号是二端口网络+振幅

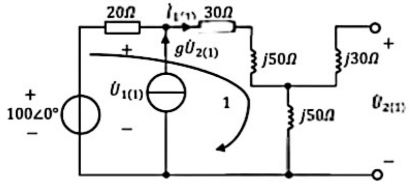
(1)当$U_s=50V$单独作用时，电路如下图所示



$$I_{1(0)}=\frac{50}{20+30}=1A$$

$$P_0=I_{1(0)}^2\times R_2=30W$$

当$\dot{U}_s=100\angle 0°V$时，电路如下图所示



对回路 1 列KVL可得

$$20\left(\dot{I}_{1(1)}-g\dot{U}_{2(1)}\right)+(30+j100)\dot{I}_{1(1)}-100\angle 0°=0$$

$$\dot{U}_{2(1)}=\dot{I}_{1(1)}\cdot j50$$

解得

$$\dot{I}_{1(1)}=2\angle 0°$$

$$P_{(1)}=I_{1(1)}^2R_2=120W$$

则

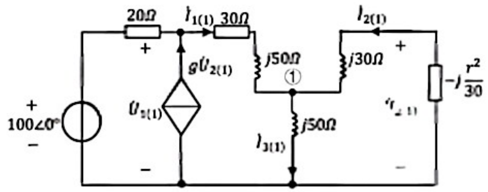
$$P=P_{(0)}+P_{(1)}=150W$$

(2)回转器方程

$$\begin{cases}\dot{U}_2=-r\cdot\dot{I}_3\\ \dot{U}_3=r\cdot\dot{I}_2\end{cases}$$

$$\frac{\dot{U}_{2(1)}}{\dot{I}_{3(1)}}=\frac{-r\dot{I}_{3(1)}}{\frac{\dot{U}_{3(1)}}{r}}=-r^2\frac{\dot{I}_{3(1)}}{\dot{U}_{3(1)}}=-r^2\frac{1}{j\omega L_3}=-j\frac{r^2}{30}\Omega$$

电路等效如下图所示



对1节点列KCL可得

$$\dot{I}_{1(1)}+\dot{I}_{2(1)}=\dot{I}_{3(1)}$$

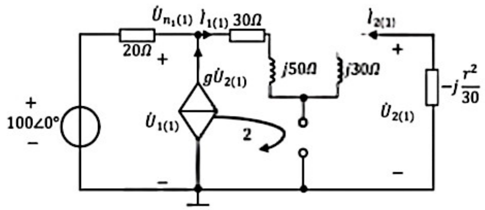
若要使$I_{1(1)}=I_{2(1)}$，则必有

$$\dot{I}_{3(1)}=0$$

故电路最右侧发生串联谐振，则

$$j\left(30-\frac{r^2}{30}\right)=0\Rightarrow r=30\,\Omega$$

电路再次等效如下图所示



列写节点电压方程

$$\begin{cases}\left(\dfrac{1}{20}+\dfrac{1}{30+j50}\right)\dot{U}_{n_1(1)}=\dfrac{100\angle 0^\circ}{20}+0.1\dot{U}_2\\ \dot{U}_{2(1)}=\dfrac{\dot{U}_{n(1)}}{30+j50}\times(-j30)\end{cases}$$

解得

$$\dot{U}_{n_1}=48.26\angle-6.52^\circ V;\ \dot{U}_{2(1)}=24.83\angle-155.56^\circ V$$

则

$$u_2(t)=24.83\sqrt{2}\sin(\omega t-155.56^\circ)V$$

$$P_{R_2}=30+\left(\frac{U_{n_1}}{\sqrt{30^2+50^2}}\right)^2\times 30=50.55W$$

(3)设$\dot{I}_1$　I ，$\angle 0^\circ$，则

$$\dot{U}_{2(1)}=-j30\cdot I_{1(1)}\angle 0^\circ=30I_{1(1)}\angle-90^\circ=U_{2(1)}\angle-90^\circ$$

那么

$$g\cdot\dot{U}_{2(1)}=gU_{2(1)}\angle-90^\circ$$

$$\frac{g\cdot\dot{U}_{2(1)}}{\dot{U}_1\angle\varphi_{u_1}}=\frac{gU_2}{U_1}\angle-135^\circ$$

则

$$\varphi_{u_1}=45^\circ$$

对回路 2 列KVL可得

$$\dot{I}_{1(1)}(R_2+j50)=U_1\angle 45^\circ$$

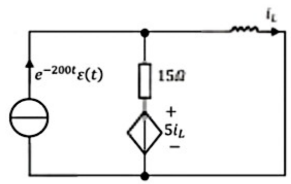
$$I_1\quad(R+j50)=U_1\angle 45^\circ$$

故

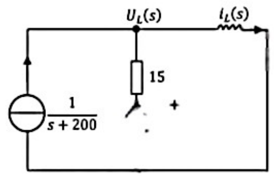
$$R=50\Omega$$

八、**【分析】**

(1)



作运算电路图如下图所示：



列节点电压方程可得：

$$\begin{cases}\left(\frac{1}{15}+\frac{1}{0.1s}\right)U_L(s)=\frac{1}{s+200}+\frac{1}{3}I_L(s)\\ U_L(s)=0.1s\cdot I_L(s)\end{cases}$$

整理可得

$$I_L(s)=\frac{150}{(s+100)(s+200)}=\frac{1.5}{s+100}+\frac{-1.5}{s+200}$$

则

$$i_L(t)=(1.5e^{-100t}-1.5e^{-200t})\varepsilon(t)A$$

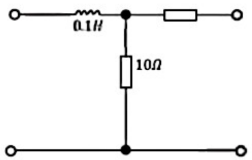
(2)当K_1闭合时

$$\tau=\frac{1}{100}=\frac{0.1}{R_{eq}}$$

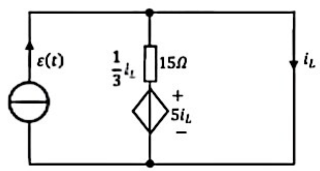
解得

$$R_{eq}=10\Omega$$

要使K_1闭合时$i_L(t)$为K_1打开时的 2 倍，则K_1打开后，电路时间常数不变，$i_L(\infty)$为原来的一半，故可将P等效为如下图所示



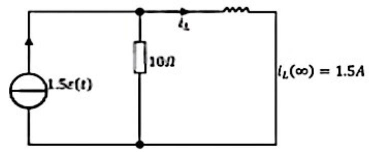
当K_1闭合时电路达到稳态，如下图所示



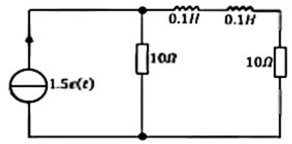
$$i_L=\frac{1}{3}i_L+1$$

$$i_L(0_-)=1.5A$$

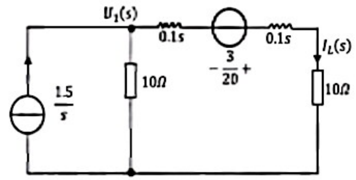
对L左侧进行戴维南等效，如下图所示



当K_1打开时，电路图如下图所示：



作运算电路模型如下图所示



列节点电压方程可得

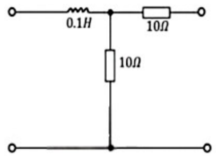
$$\left(\frac{1}{10}+\frac{1}{10+0.2s}\right)U_1(s)=\frac{1.5}{s}-\frac{\frac{3}{20}}{10+0.2s}$$

$$U_1(s)=\frac{7.5s+750}{s(s+100)}$$

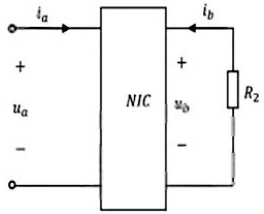
$$I_L(s)=\frac{1.5}{s}-\frac{1}{10}U_1(s)=\frac{1.5}{s}-\frac{0.75s+75}{s(s+100)}=\frac{1.5}{s}-\frac{0.75}{s}=\frac{0.75}{s}$$

所以$i_L(t)=\frac{3}{4}\varepsilon(t)A$，无过渡过程。

(3)要使$i_L(t)=2i_2(t)$，故可将P进一步等效为如下图所示

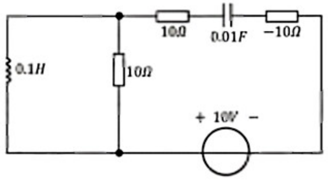


对NIC及其右侧电路进行等效如下图所示

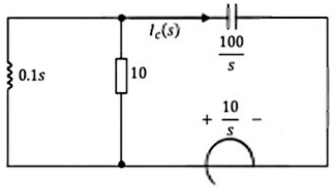


$$\frac{u_a}{i_a}=\frac{u_b}{i_b}=-R_2=-10\Omega$$

原电路可等效如下图所示



作运算电路模型如下图所示



$$I_C(s)=\frac{\frac{10}{s}}{0.1s//10+\frac{100}{s}}=\frac{s+100}{s^2+10s+1000}$$

$$\Delta=10^2-4\times1000=-3900<0$$

所以电容电流震荡。