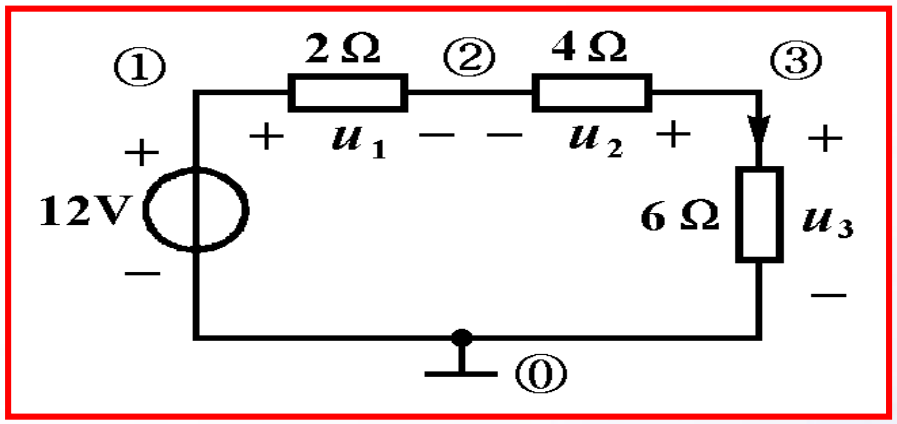
第2章 电阻电路

作业(P90-100)：

2-1、2-8、2-14、4-3、4-5 、4-8、4-9、4-15、

4-16、4-20、4-24 、6-1(并求等效电路)

2-1 求图中的各电压或电流值。



(a)

串联分压：

$$u_1 = 12V \times \frac{2}{2+4+6} = 2V$$

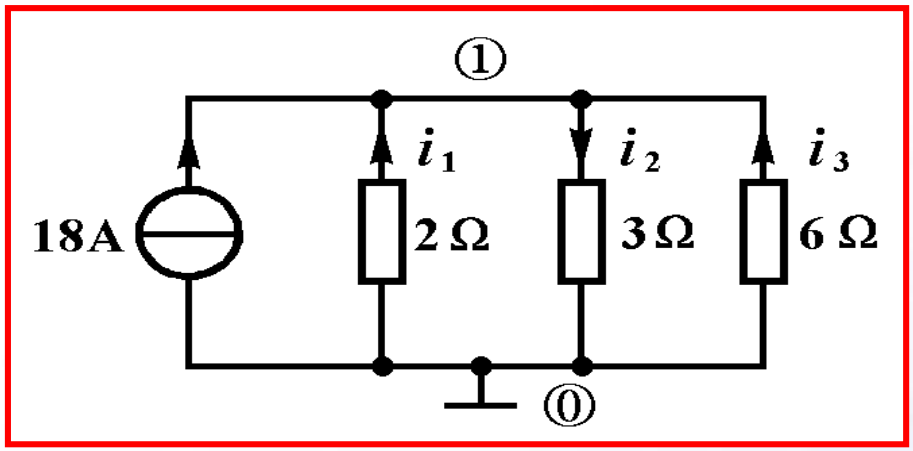
$$u_2 = -12V \times \frac{4}{2+4+6} = -4V$$

$$u_3 = 12V \times \frac{6}{2+4+6} = 6V$$

分压公式 ——$u_k(t) = \dfrac{R_k}{\sum_{i=1}^{n} R_i} u_s(t) \qquad k = 1,2,\cdots,n$

注意参考电压方向：参考方向与电源方向相反，取正值；否则取负值。

2-1 求图中的各电压或电流值。



(b)

并联分流：G=1/R

$$i_1 = -\frac{G_1}{G_1+G_2+G_3}\times 18A = -9A$$

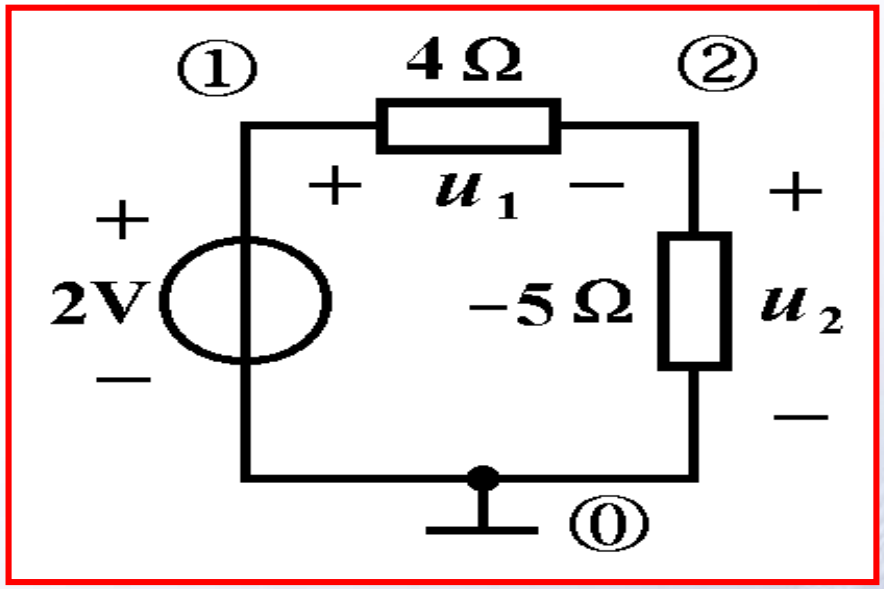
$$i_2 = \frac{G_2}{G_1+G_2+G_3}\times 18A = 6A$$

$$i_3 = -\frac{G_3}{G_1+G_2+G_3}\times 18A = -3A$$

分流公式——$i_k(t) = \dfrac{G_k}{\sum_{i=1}^{n} G_i} i_s(t) \qquad k = 1,2,\cdots,n$

注意参考电流方向：参考方向与电源电流方向相反，取正值；否则取负值。

2-1 求图中的各电压或电流值。



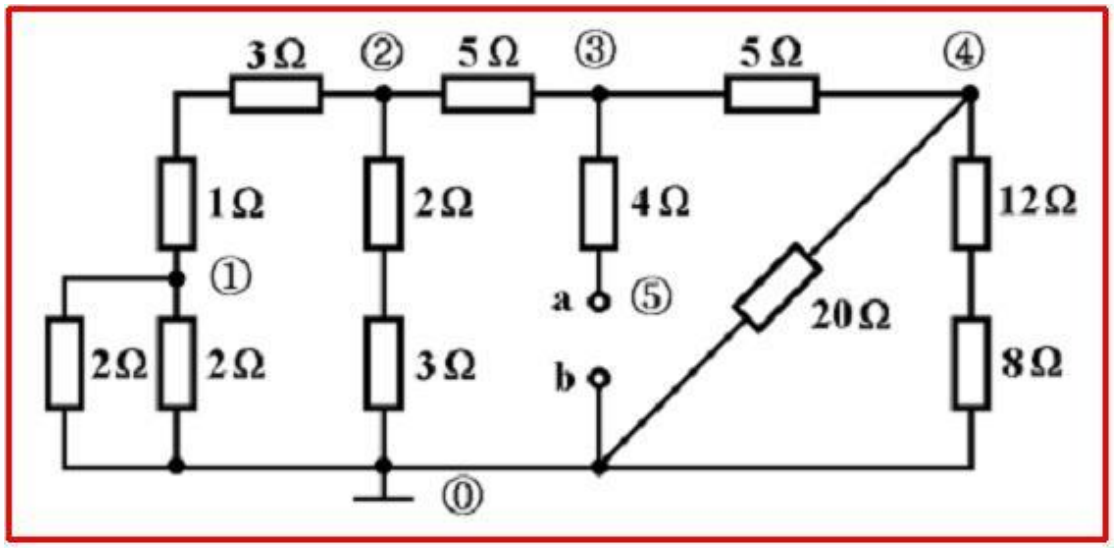
(c)

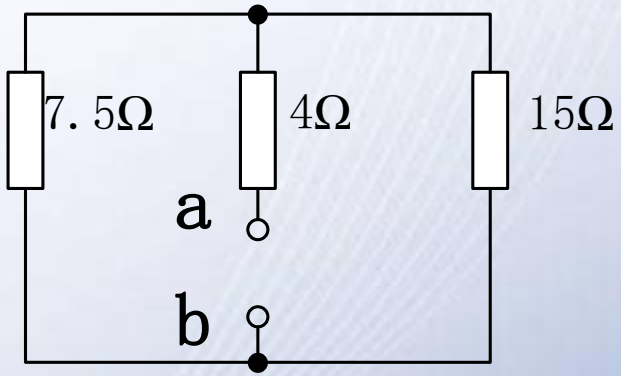
串联分压：

$$u_1 = 2V \times \frac{4}{4+(-5)} = -8V$$

$$u_2 = 2V \times \frac{-5}{4+(-5)} = 10V$$

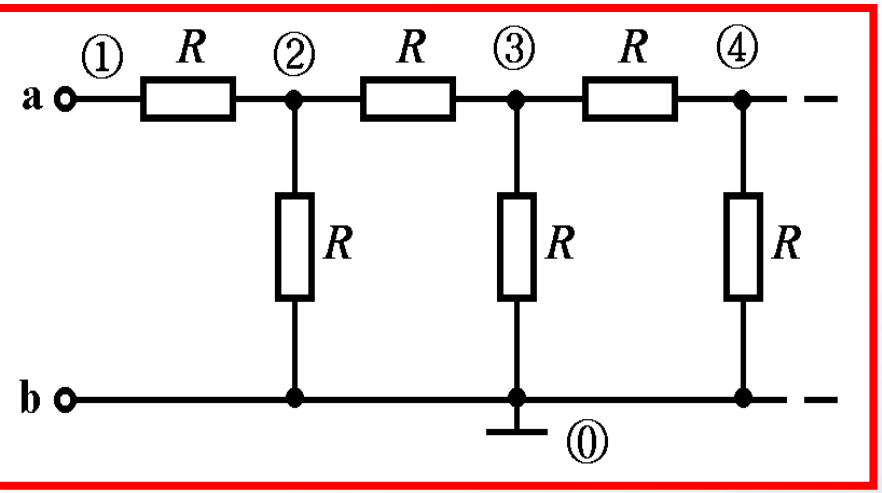
2-8 求图中电阻单口的等效电阻Rab。



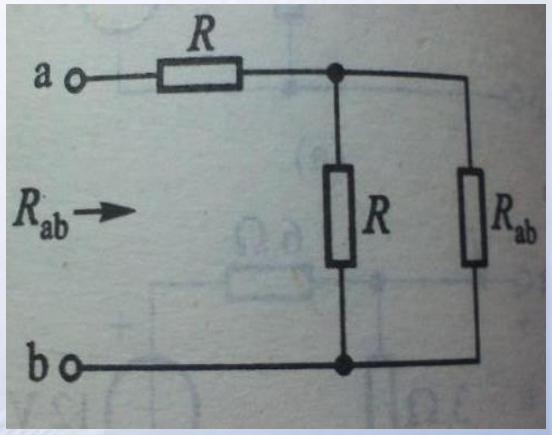


$$R_{ab} = 4\Omega + \frac{(5\Omega + 2.5\Omega)(5\Omega + 10\Omega)}{5\Omega + 2.5\Omega + 5\Omega + 10\Omega} = 4\Omega + 5\Omega = 9\Omega$$

2-14 求图中所示无限长梯形网络等效电阻Rab。



梯形网络无限长

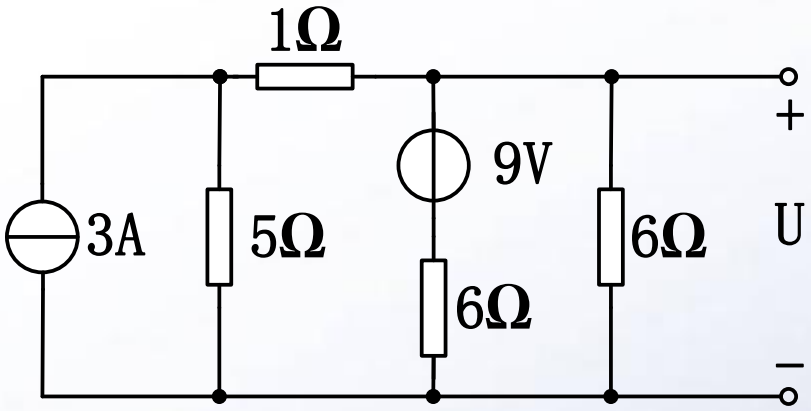


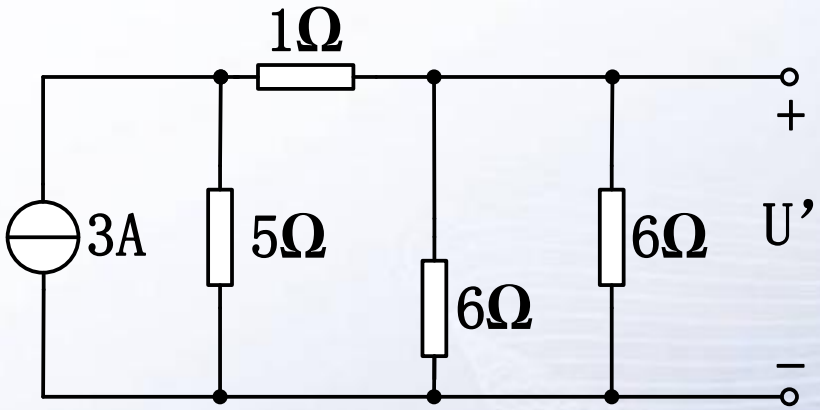
$$R_{ab} = R + \frac{RR_{ab}}{R + R_{ab}}$$

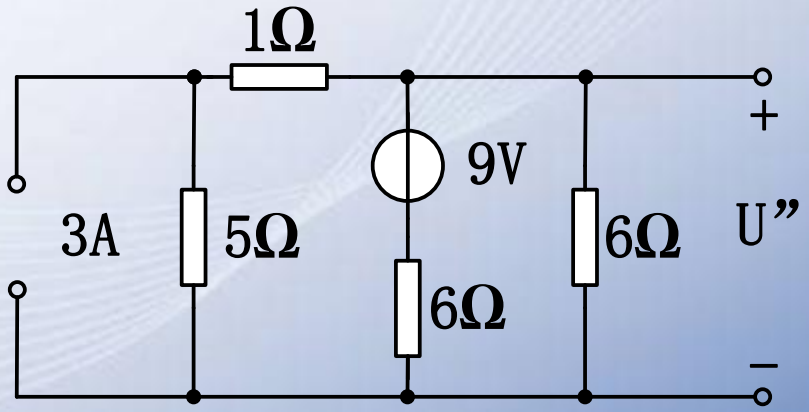
$$R_{ab}^{\ 2} - RR_{ab} - R^2 = 0$$

$$R_{ab} = \frac{1+\sqrt{5}}{2} R = 1.618R$$

4-3 用叠加定理求图中电压U





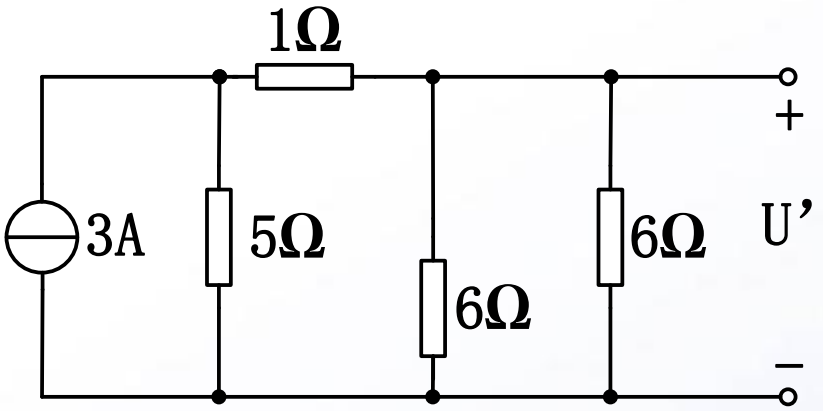


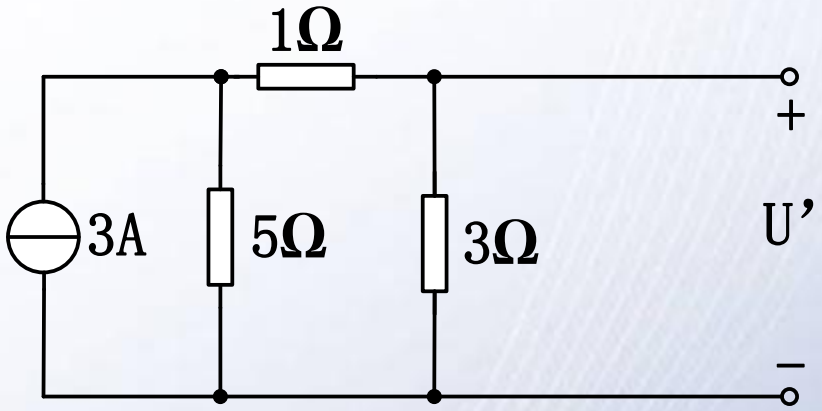
只考虑电流源作用：

电压源短路

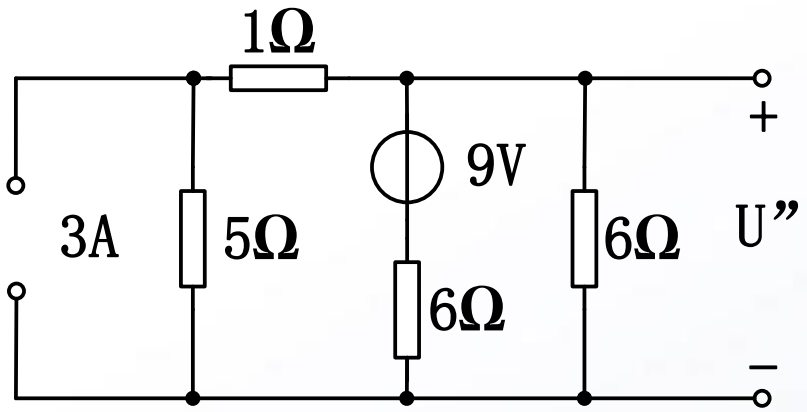
只考虑电压源作用：

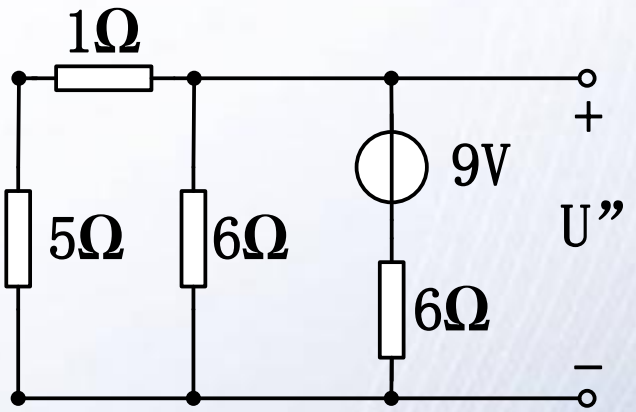
电流源开路





$$u' = 3A \times \frac{\dfrac{1}{(1\Omega + 3\Omega)}}{\dfrac{1}{5} + \dfrac{1}{(1\Omega + 3\Omega)}} \times 3\Omega = 3A \times \frac{5\Omega}{5 + (1\Omega + 3\Omega)} \times 3\Omega = 5V$$

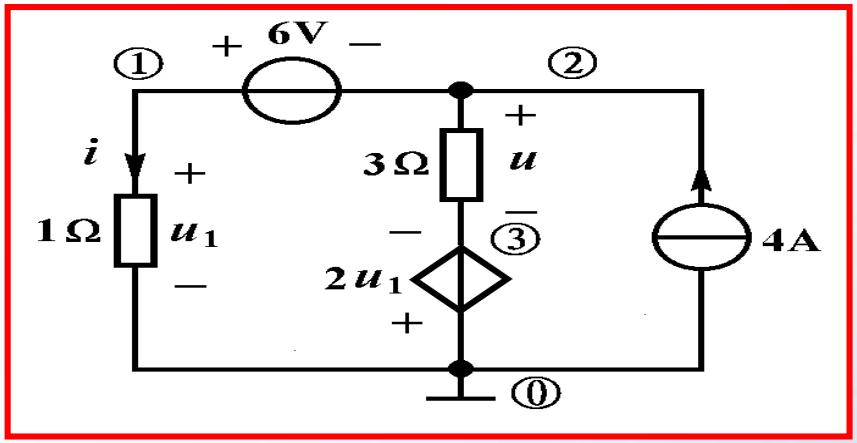


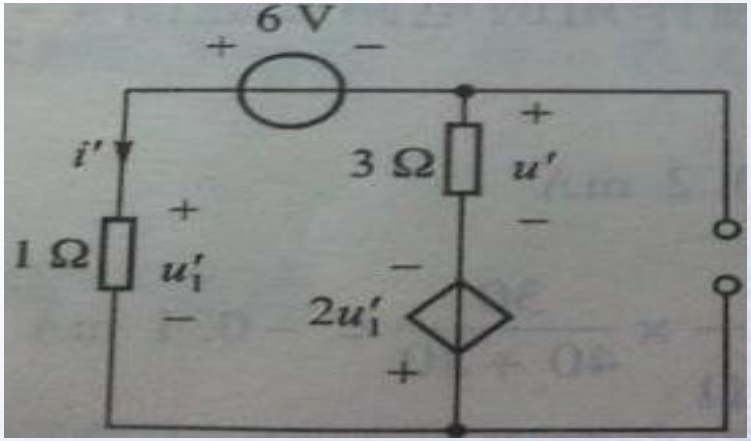


$$u'' = \frac{3\Omega}{6\Omega + 3\Omega} \times 9V = 3V$$

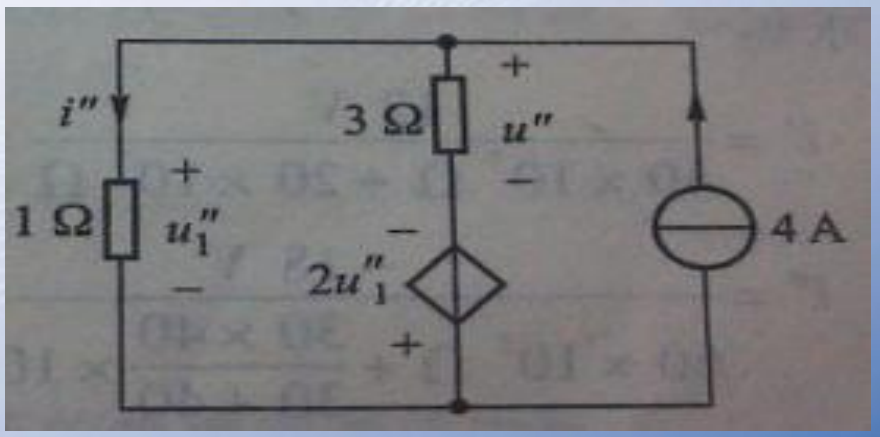
$$u = u' + u'' = 8V$$

4-5 用叠加定理求图中电流i和电压u



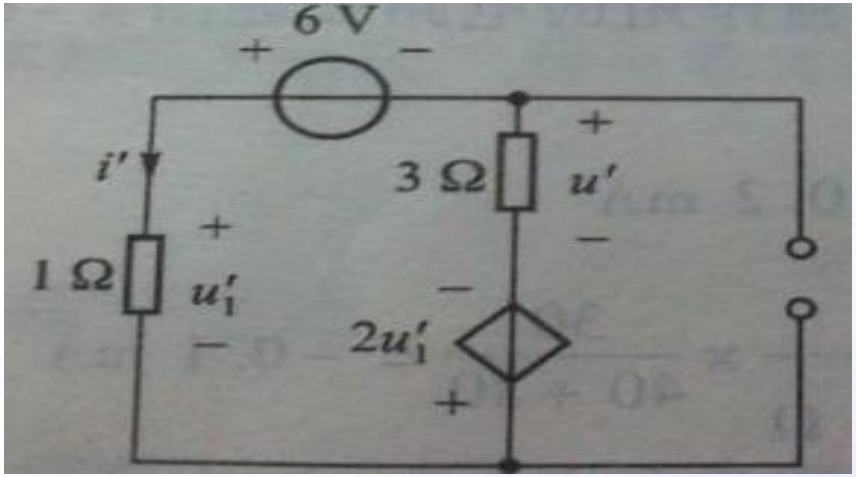


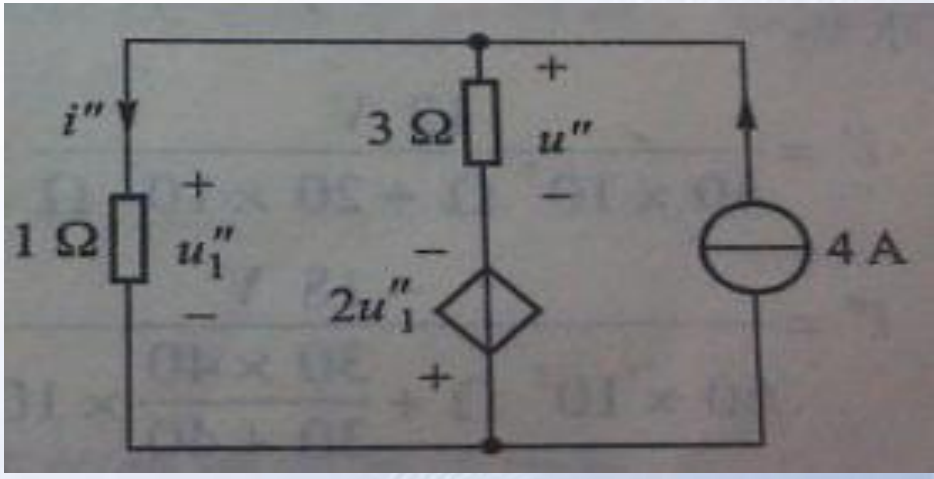
只考虑电压源作用



只考虑电流源作用

4-5 用叠加定理求图中电流i和电压u





KVL　逆时针

$$(1\Omega+3\Omega)\times i'+2u_1'-6V=0$$

$$u_1'=1\Omega\times i'$$

$$\Rightarrow i'=1A$$

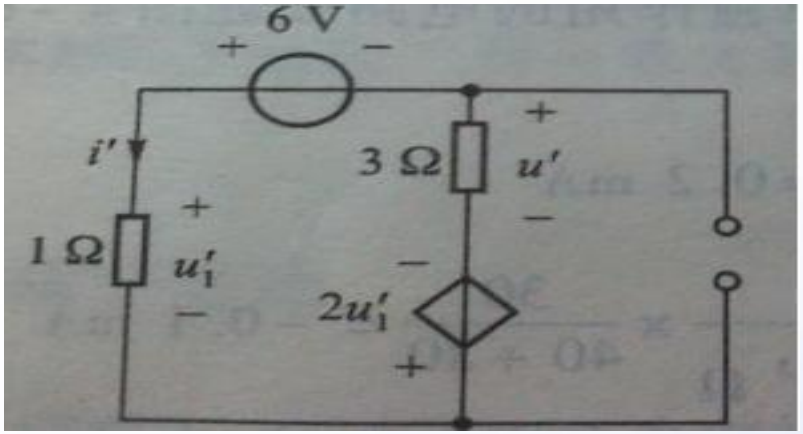
KVL　逆时针

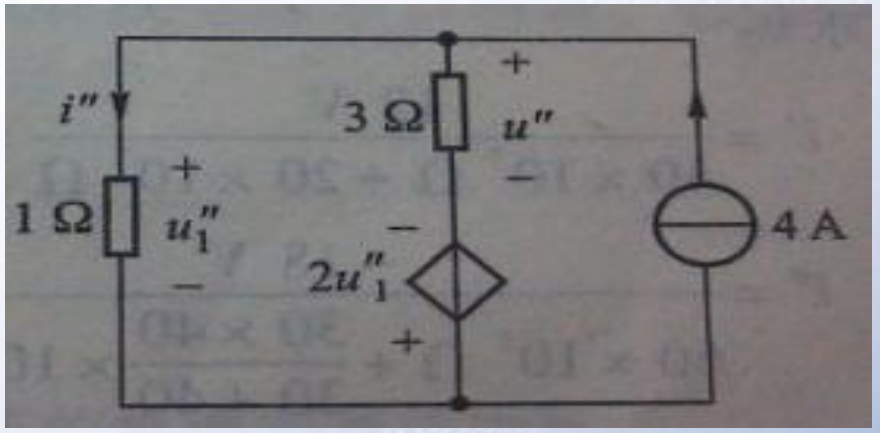
$$1\Omega\times i''+2u_1''+3\Omega\times(i''-4A)=0$$

$$u_1''=1\Omega\times i''$$

$$\Rightarrow i''=2A$$

4-5 用叠加定理求图中电流i和电压u





$$i' = 1A$$

$$\rightarrow u' = -3 \times i' = -3V$$

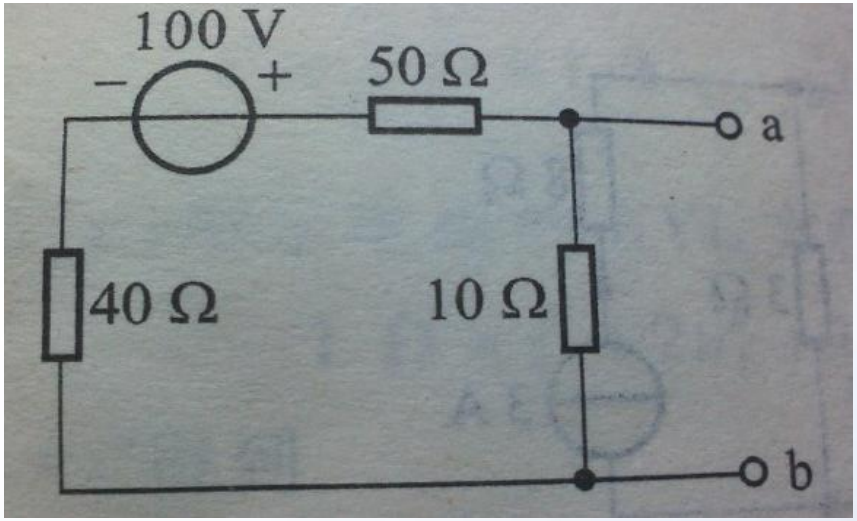
$$i'' = 2A$$

$$\rightarrow u'' = (4 - i'') \times 3\Omega = 6V$$

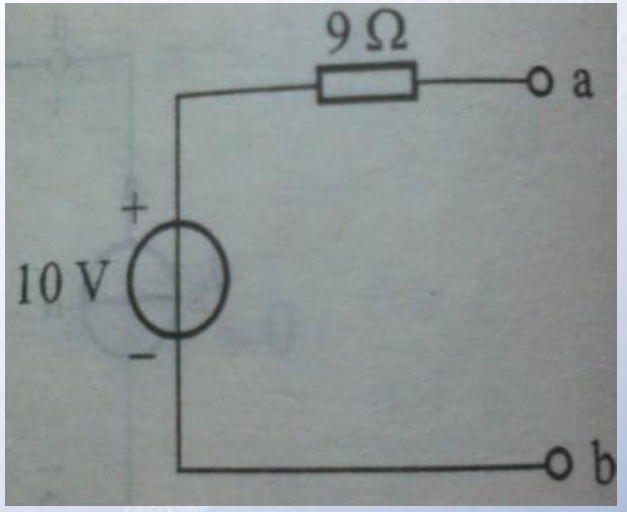
$$i = i' + i'' = 3A$$

$$u = u' + u'' = 3V$$

4-8 计算图中各单口网络的戴维宁等效电路



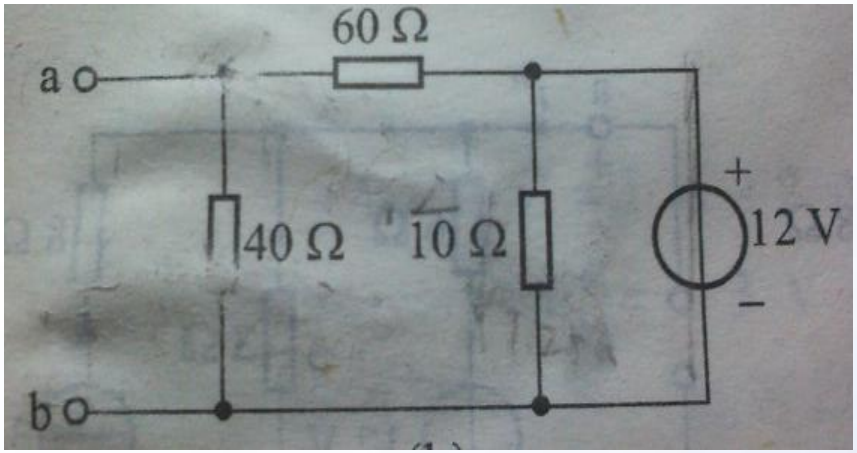
(a)



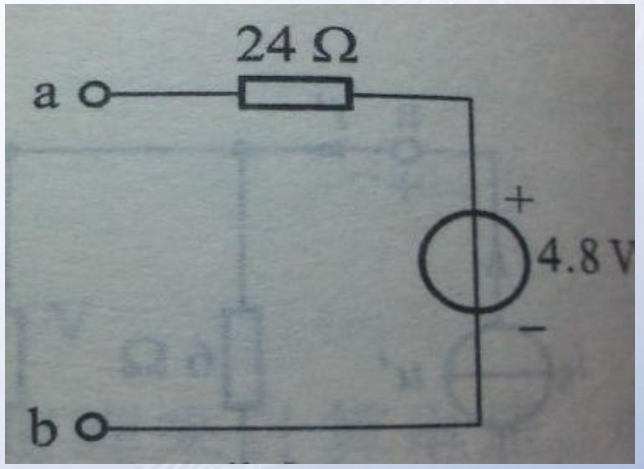
a、b间开路 $u_{oc} = \dfrac{10}{40+50+10} \times 100V = 10V$

电压源短路 $R_o = \dfrac{90 \times 10}{90+10} = 9\Omega$

4-8 计算图中各单口网络的戴维宁等效电路



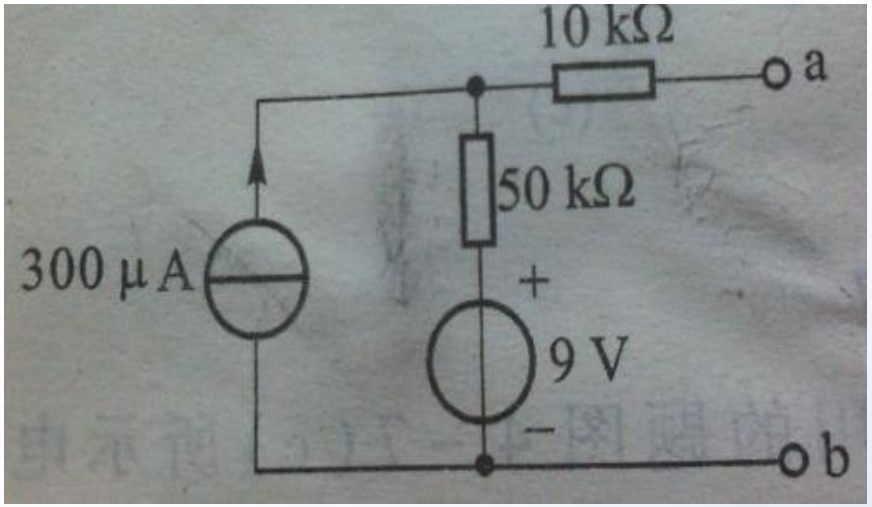
(b)



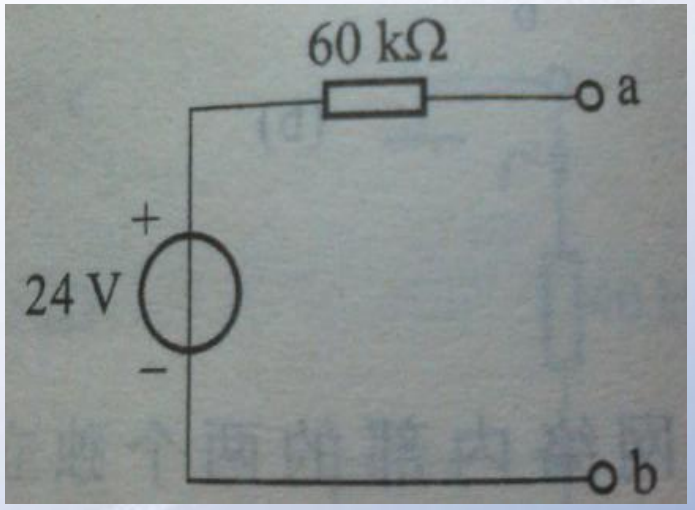
a、b间开路 $u_{oc}=\dfrac{40}{60+40}\times 12\text{V}=4.8\text{V}$

电压源短路 $R_o=\dfrac{60\times 40}{60+40}=24\Omega$

4-8 计算图中各单口网络的戴维宁等效电路



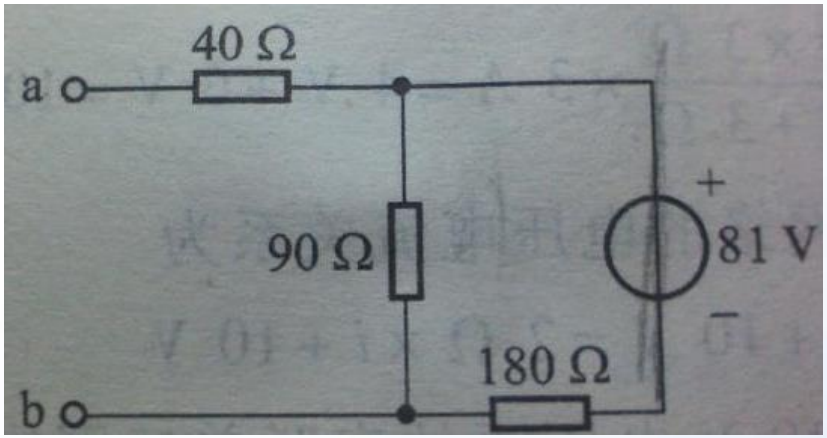
(c)



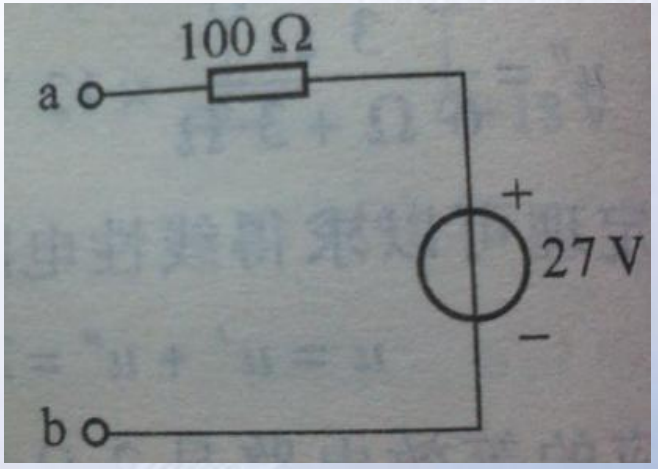
a、b间开路 $u_{oc} = 9V + 50 \times 10^{3} \times 300 \times 10^{-6} V = 24V$

电流源开路, 电压源短路 $R_o = 10 + 50 = 60k\Omega$

4-8 计算图中各单口网络的戴维宁等效电路



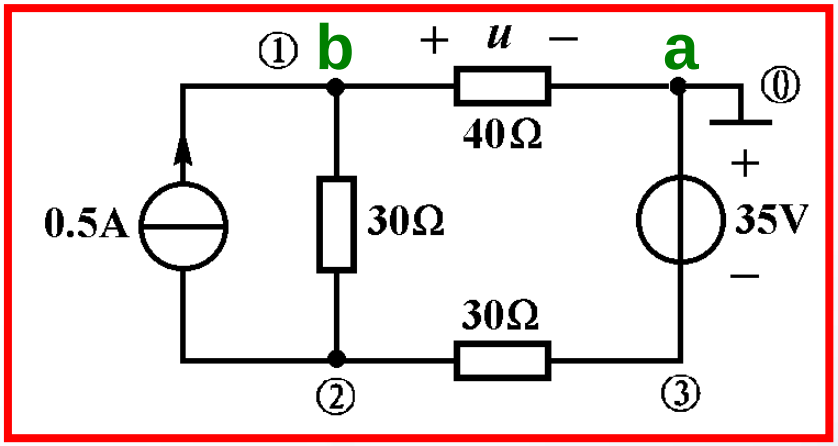
(d)

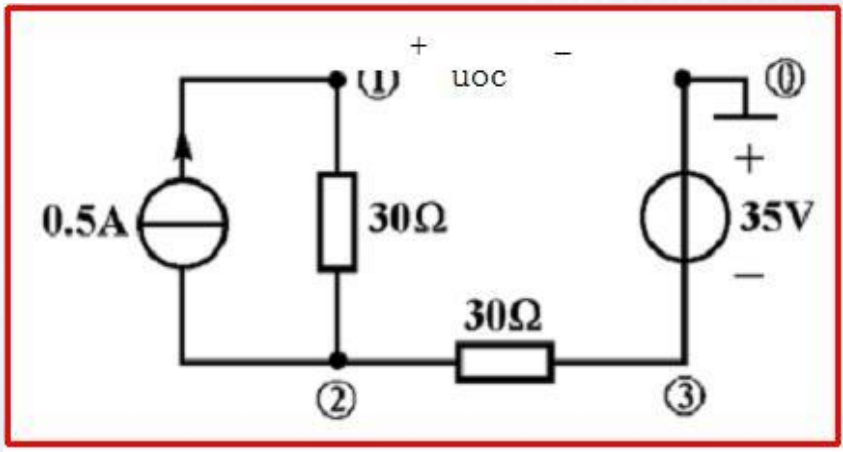


a、b间开路 $u_{oc}=\dfrac{90}{90+180}\times 81\text{V}=27\text{V}$

电压源短路 $R_o=40+\dfrac{90\times 180}{90+180}=100\Omega$

4-9 用戴维宁定理求图中电压u

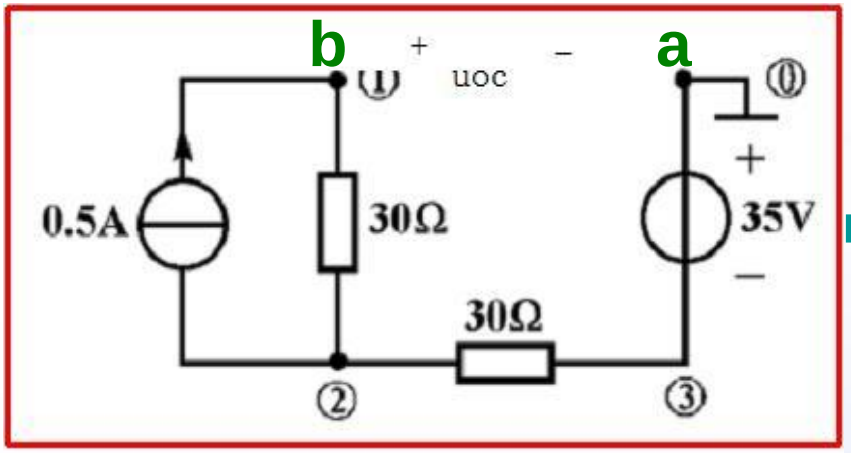


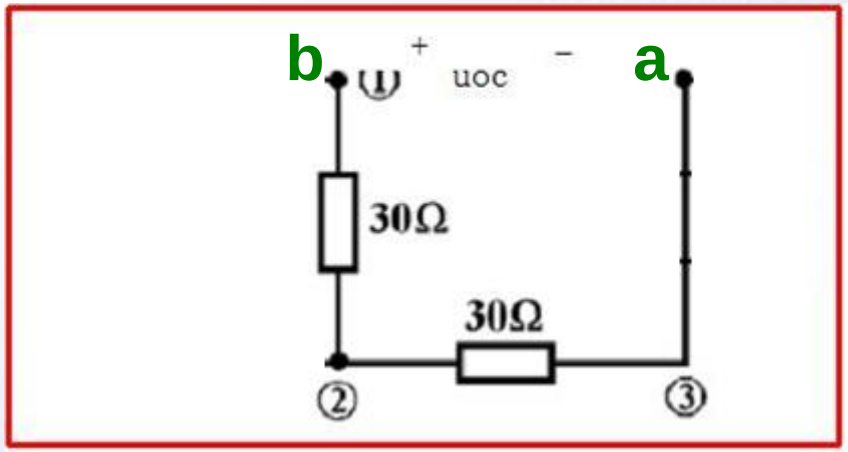


$$u_{oc} = 0.5\times 30 + 0\times 30\text{-}35 = \text{-}20\text{V}$$

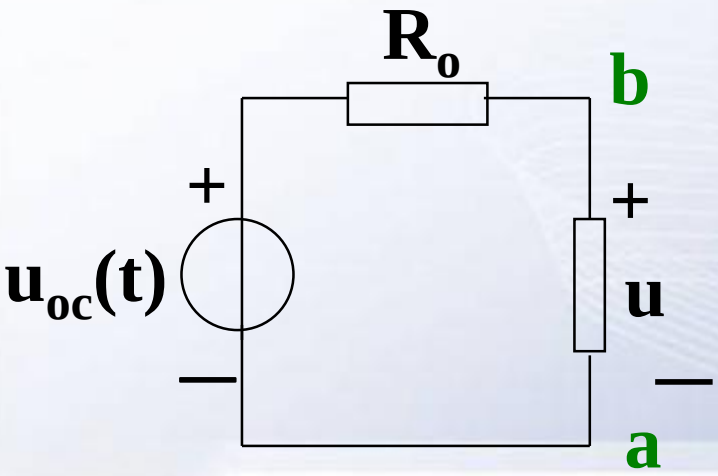
4-9 用戴维宁定理求图中电压u

电流源开路，电压源短路：





$$R_o = 30+30=60\Omega$$

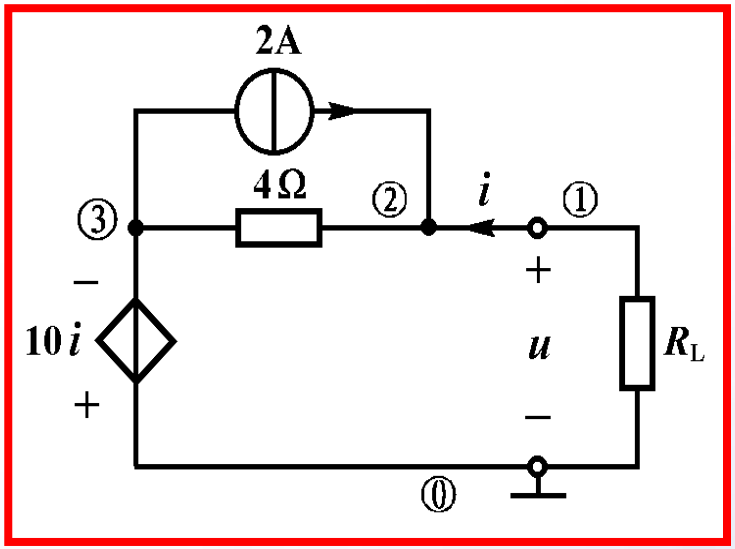


$$u_{oc} = -20\text{V}$$

$$R_o = 60\Omega$$

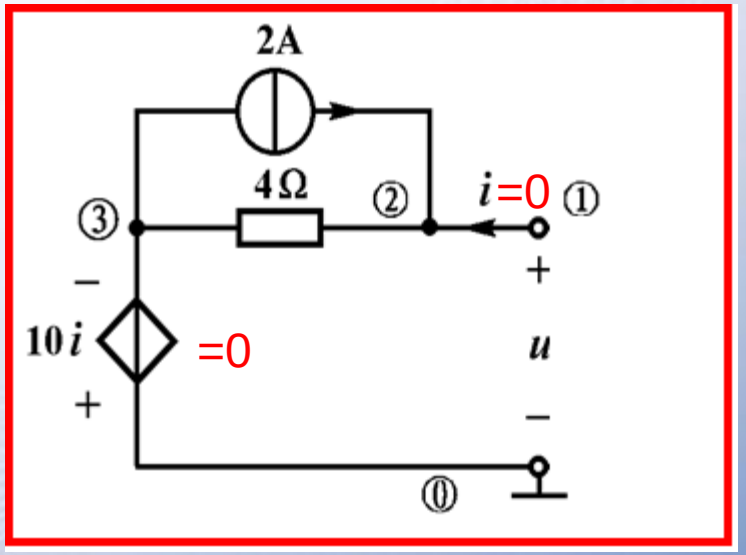
$$u = \frac{40}{40+60} \times (-20\text{V}) = -8\text{V}$$

4-15 欲使图中u=20V，R_L该为何值



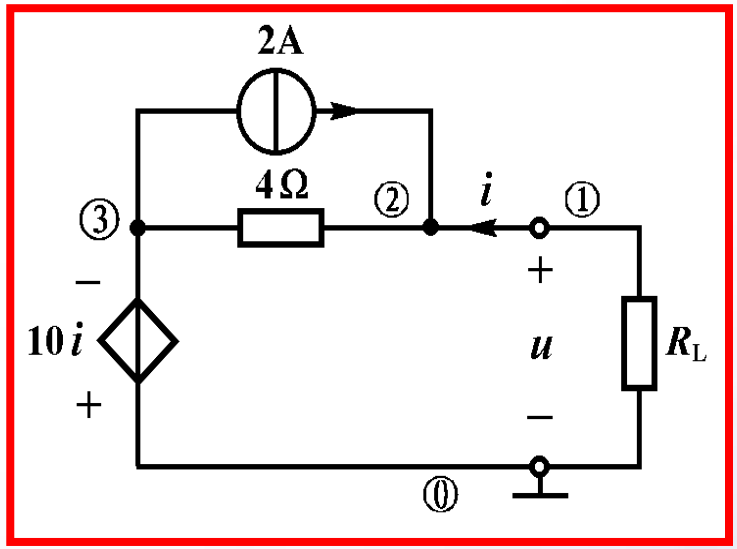
求R_L两端戴维宁等效电路：

R_L两端开路

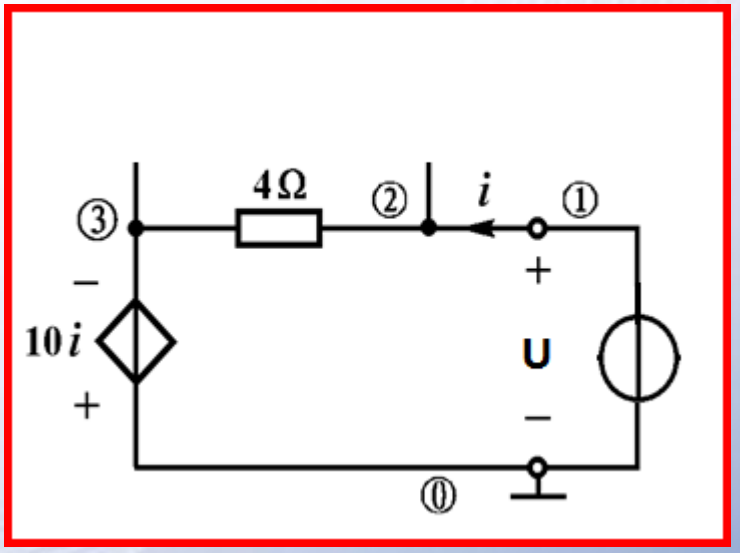


R_L两端开路 i=0，$u_{oc} = 2A \times 4\Omega + 0V = 8V$

4-15 欲使图中u=20V，R_L该为何值



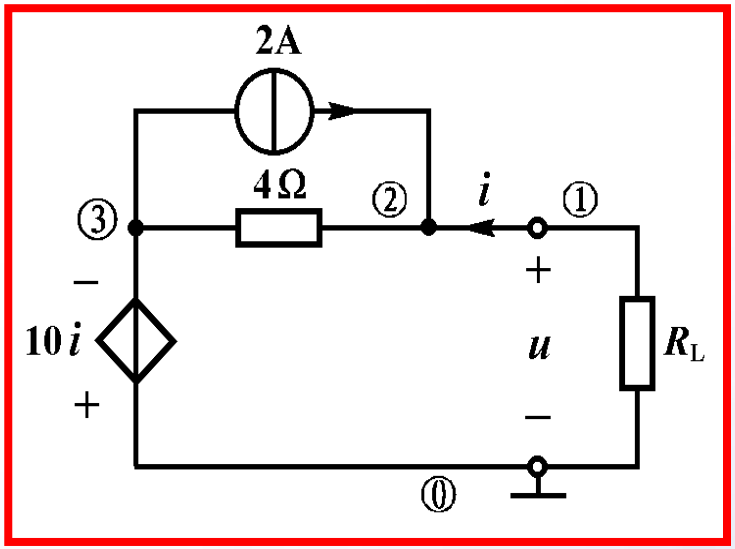
电流源开路

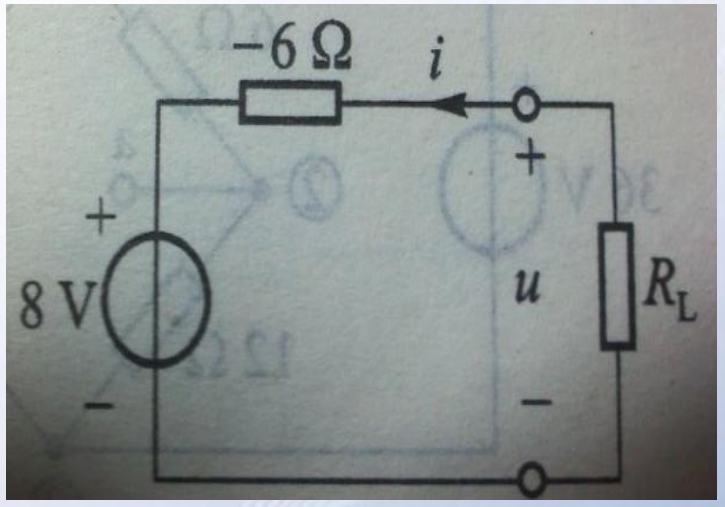


电流源开路 $U = 4\Omega \times i - 10i$

$$R_o = \frac{U}{i} = \frac{4\Omega \times i - 10i}{i} = -6\Omega$$

4-15 欲使图中u=20V，R_L该为何值





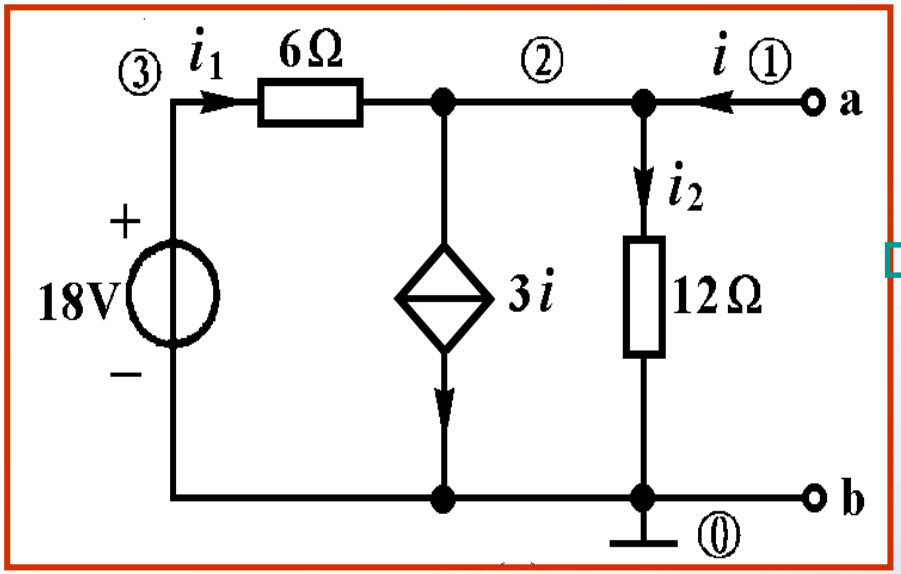
R_L两端开路 i=0，$u_{oc} = 2A \times 4\Omega + 0V = 8\text{V}$

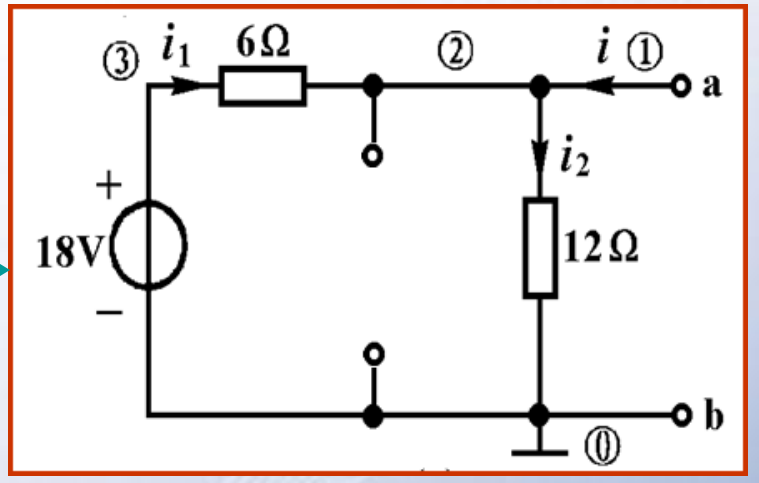
$$u = \frac{R_L}{-6 + R_L} \times 8\text{V} = 20\text{V}$$

电流源开路 $R_o = \dfrac{4\Omega \times \text{i} - 10i}{\text{i}} = -6\Omega$

$R_L = 10\Omega$

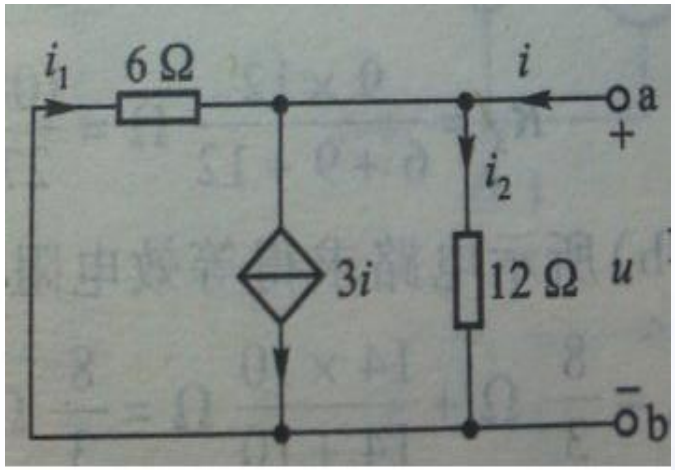
4-16 求图示单口网络的戴维宁等效电路





a、b间开路时，i=0A，$u_{oc}=18\text{V}\times\dfrac{12}{12+6}=12\text{V}$

4-16 求图示单口网络的戴维宁等效电路

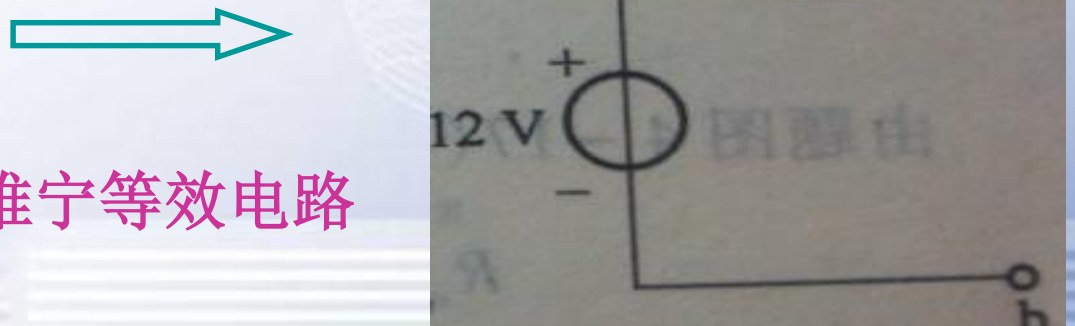


电压源短路, 加I求U

6Ω和12Ω电阻并联，先等效为一个电阻后再使用VCR方程

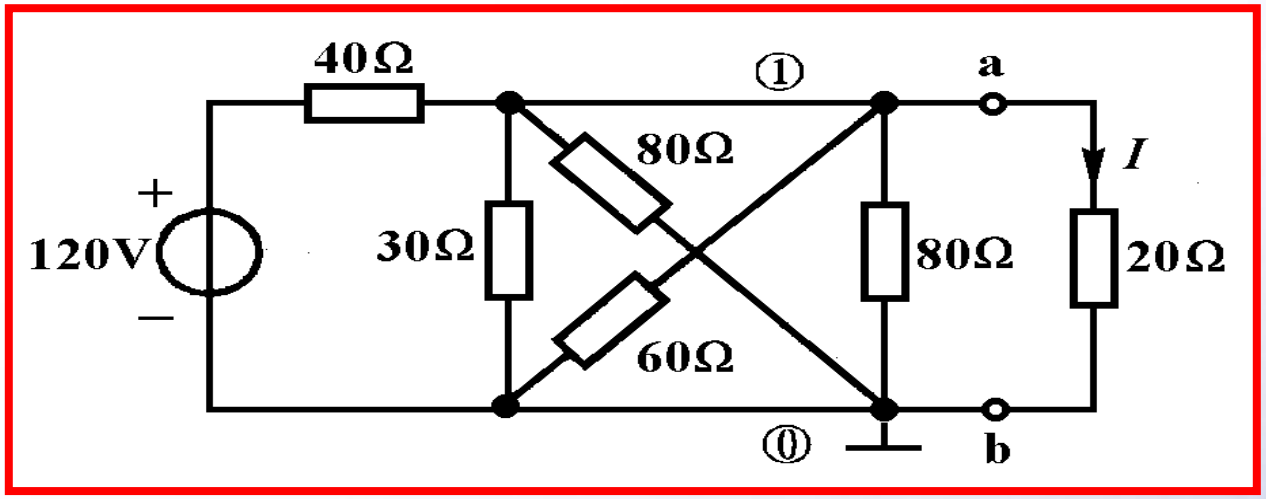
$$u = \frac{6\times 12}{6+12}\Omega \times (i - 3i) = -8i$$

$$R = \frac{u}{i} = -8\Omega$$

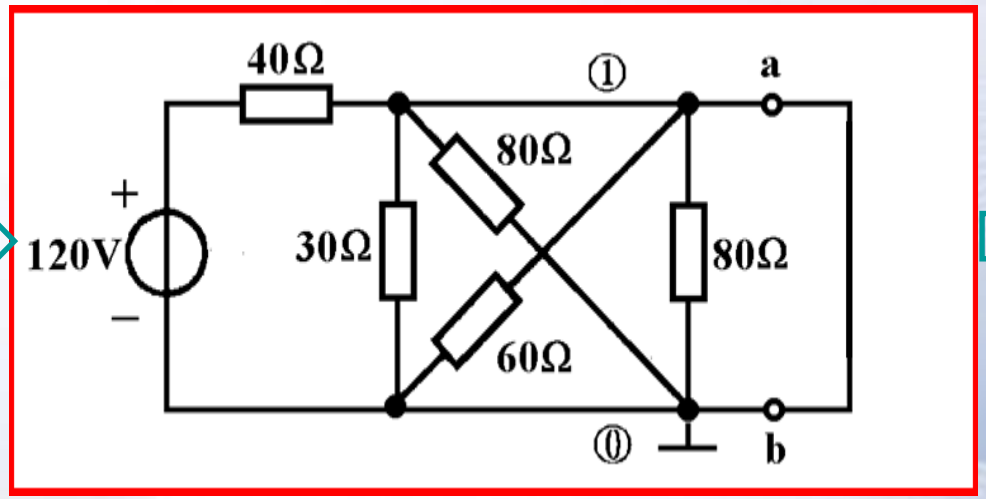


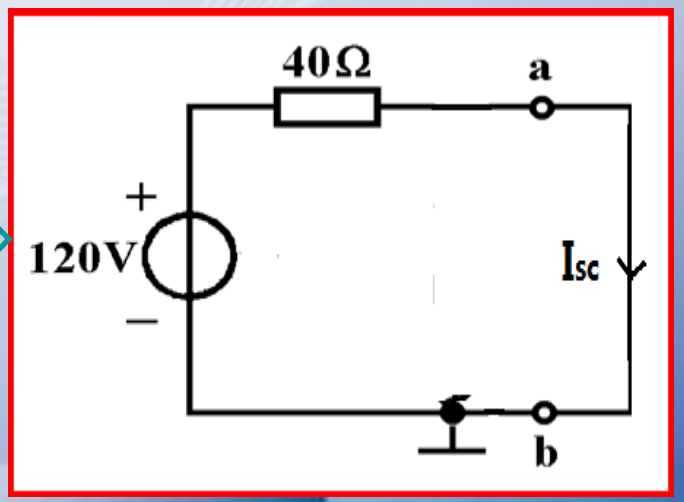
戴维宁等效电路

4-20 用戴维宁-诺顿定理求图中所示电流I

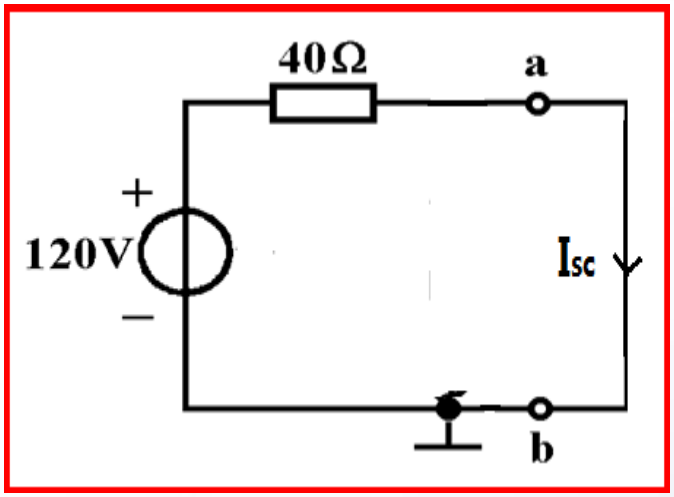


首先断开负载电阻，求出单口网络的开路电压、短路电流和输出电阻



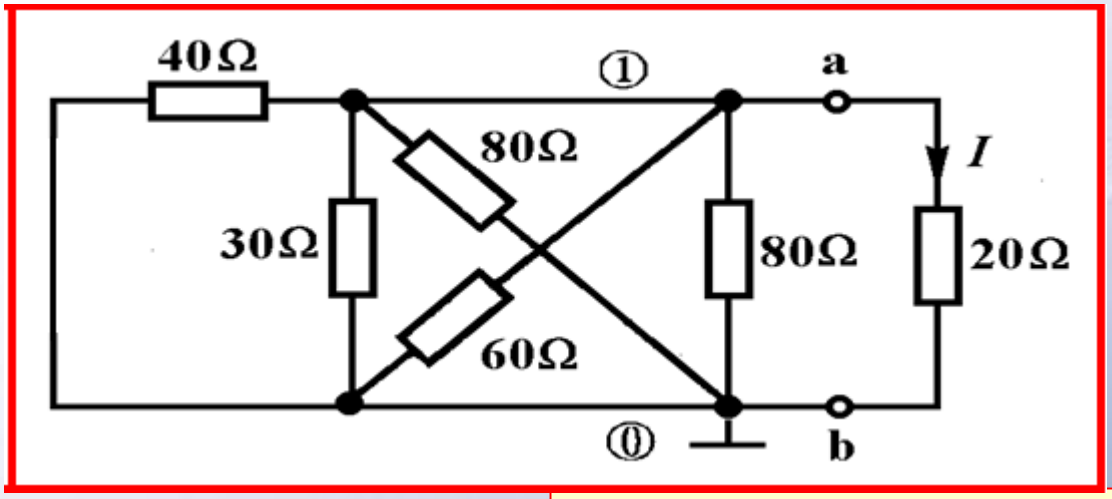


4-20 用戴维宁-诺顿定理求图中所示电流I



$$I_{sc}=\frac{120V}{40\Omega}=3\text{A}$$

电源置0(电压源短路)求R_0



$$U_{oc}=R_oI_{sc}=30V$$

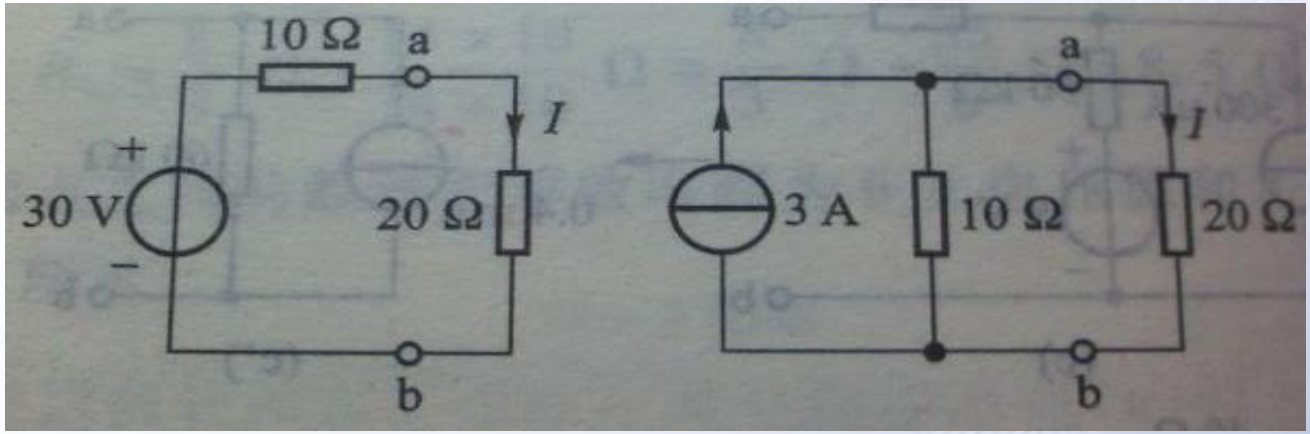
$$R_o=80//80//60//30//40=10\Omega$$

4-20 用戴维宁-诺顿定理求图中所示电流I

$I_{sc}=3\mathrm{A}$

$R_o=10\Omega$

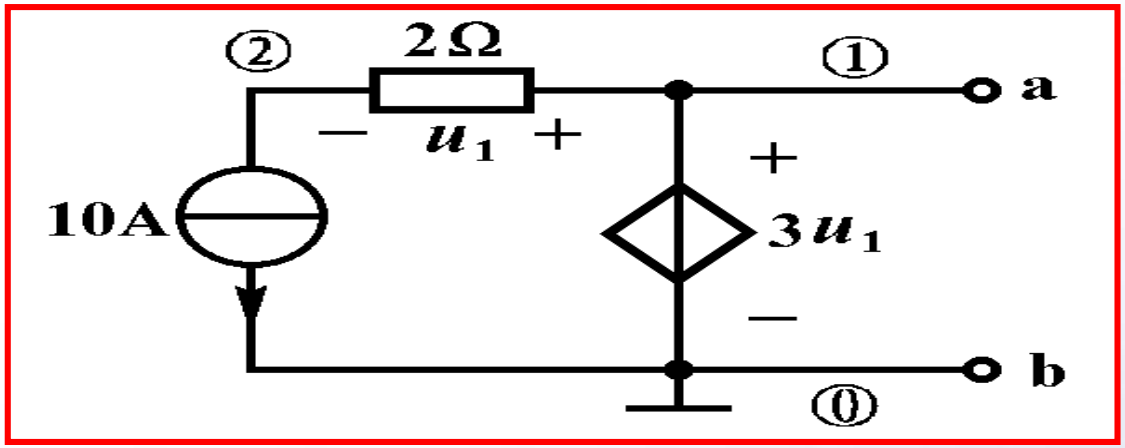
$U_{oc}=30V$

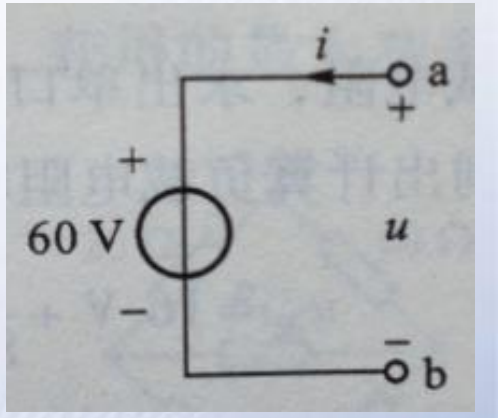


戴维宁等效电路：$I=\dfrac{30V}{10\Omega+20\Omega}=1A$

诺顿等效电路：$I=\dfrac{10\Omega}{10\Omega+20\Omega}\times 3A=1A$

4-24 求图示单口网络的戴维宁和诺顿等效电路





戴维宁等效电路

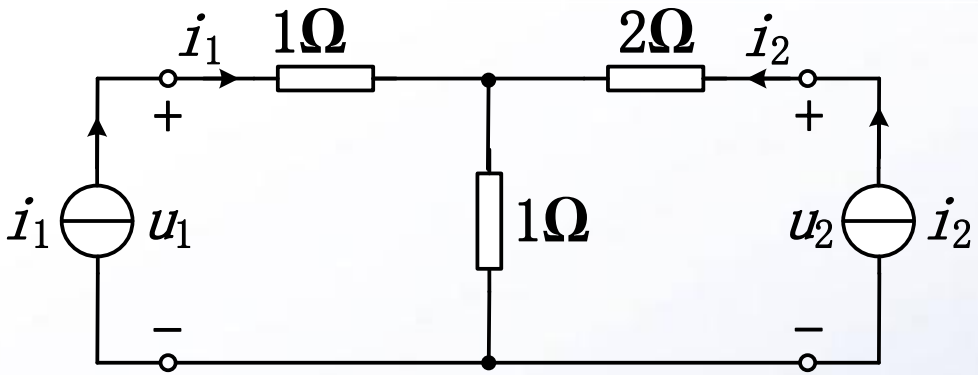
$$u_{oc} = 3u_1 = 3 \times 2\Omega \times 10A = 60\text{V}$$

10A电流源断开后 -> U1=0 -> a、b两端电压=0

输出电阻R_o=0, 等效为一个独立电压源。

不存在诺顿等效电路。

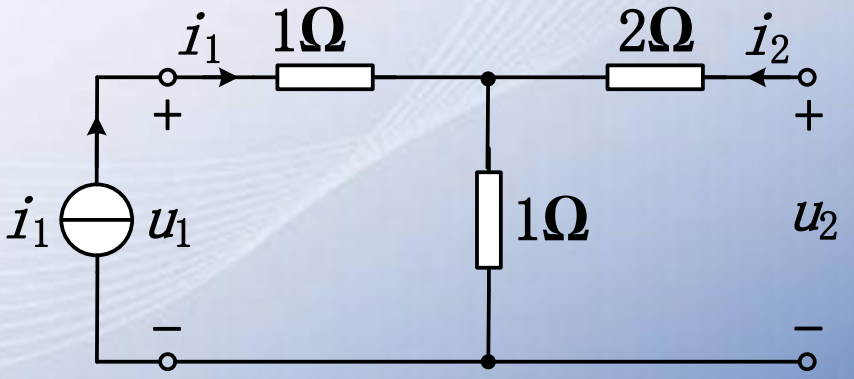
6-1 求图示双口网络的电阻参数和电导参数，并求等效电路



（a）

电阻方程（r方程）

$$u_1(t) = r_{11}i_1(t) + r_{12}i_2(t)$$
$$u_2(t) = r_{21}i_1(t) + r_{22}i_2(t)$$



解：

$$r_{11} = \left.\frac{u_1(t)}{i_1(t)}\right|_{i_2(t)=0}$$

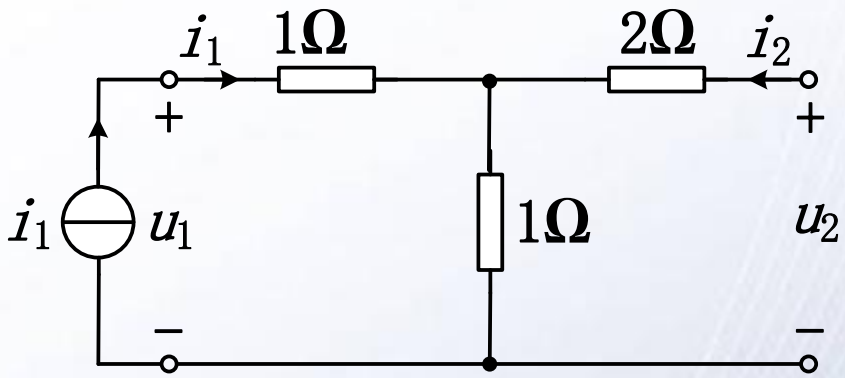
i_2=0 -> i_2开路

u_1=i_1 X 1Ω + i_1 X 1Ω

r_{11}=2Ω

6-1（a）

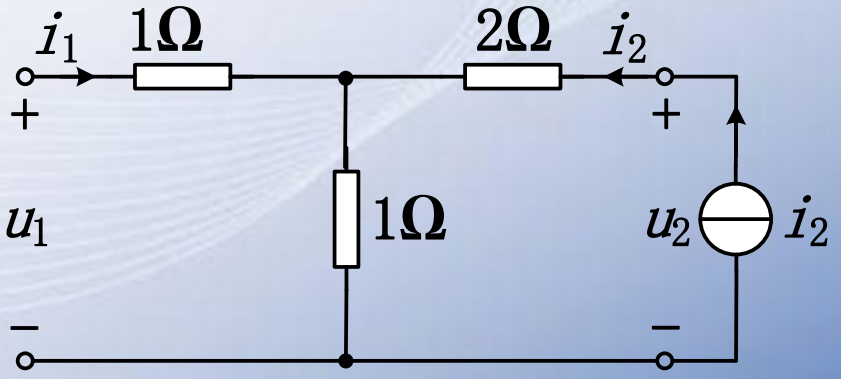
$$r_{21}=\left.\frac{u_2(t)}{i_1(t)}\right|_{i_2(t)=0}$$



i_2=0 -> i_2开路

u_2=i_1 X 1Ω　　r_{21}=1Ω

$$r_{12}=\left.\frac{u_1(t)}{i_2(t)}\right|_{i_1(t)=0}$$

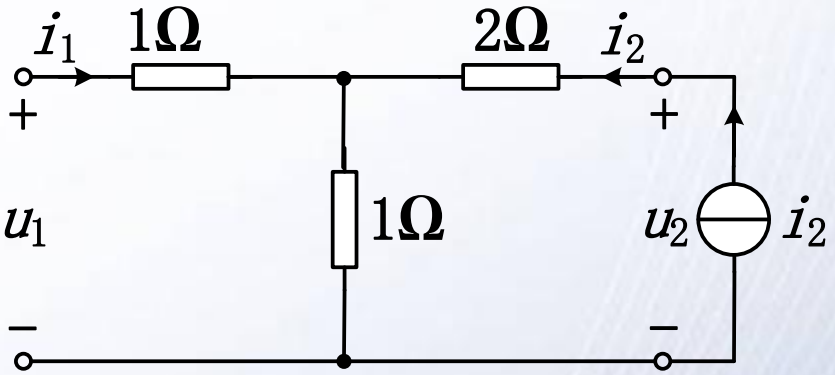


i_1=0 -> i_1开路

u_1=i_2 X 1Ω　　r_{12}=1Ω

6-1（a）

$$r_{22}=\left.\frac{u_2(t)}{i_2(t)}\right|_{i_1(t)=0}$$



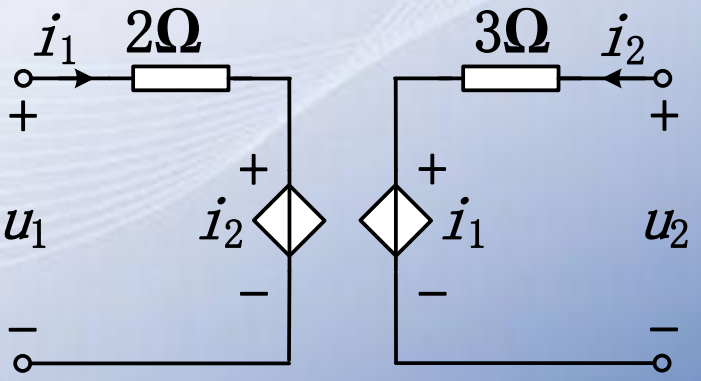
i_1=0 -> i_1开路

$u_2=i_2$ X 2Ω + i_2 X 1Ω　　r_{22}=3Ω

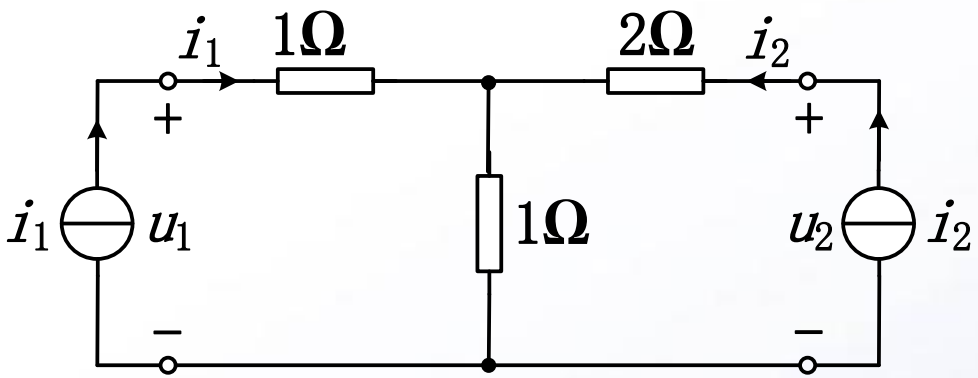
电阻等效方程：

$$u_1(t)=2i_1(t)+i_2(t)$$
$$u_2(t)=i_1(t)+3i_2(t)$$

电阻等效电路图



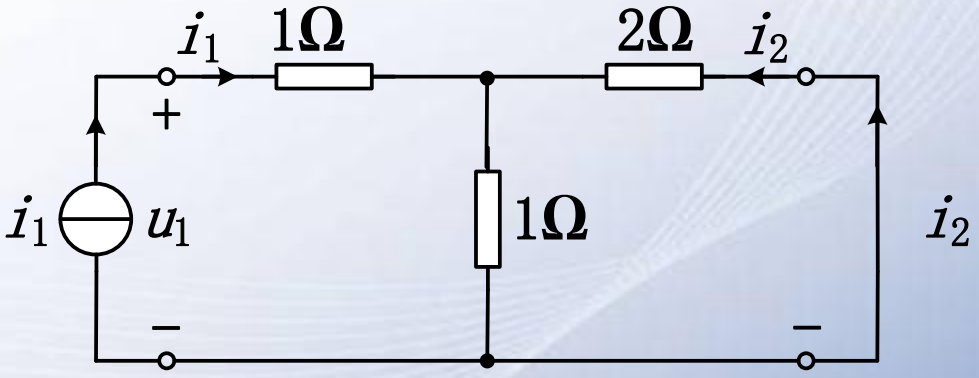
6-1（a）



电导方程（g方程）

$$i_1(t) = g_{11}u_1(t) + g_{12}u_2(t)$$
$$i_2(t) = g_{21}u_1(t) + g_{22}u_2(t)$$

$$g_{11} = \left.\frac{i_1(t)}{u_1(t)}\right|_{u_2(t)=0}$$



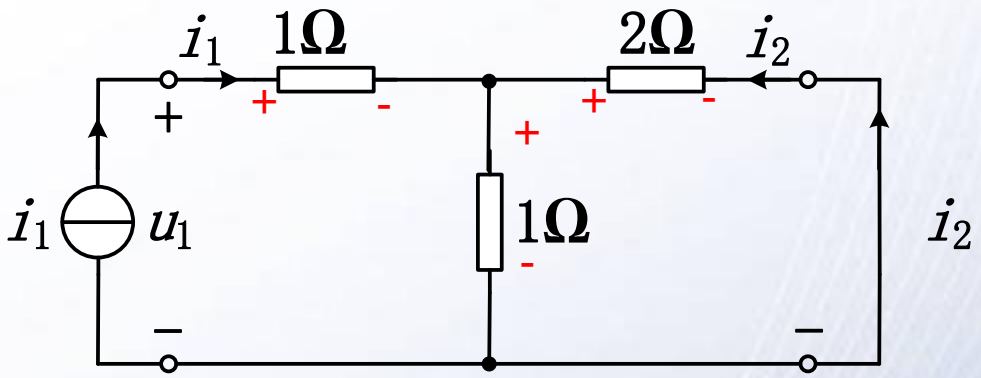
u_2=0 -> u_2短路

u_1=i_1 X (1Ω +((1*2)/(1+2))Ω)

g_{11}=0.6s

6-1（a）

$$g_{21}=\left.\frac{i_2(t)}{u_1(t)}\right|_{u_2(t)=0}$$



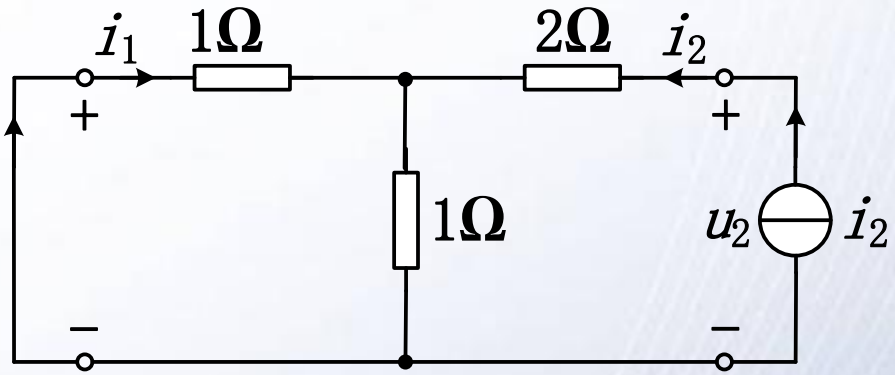
u_2=0 -> u_2短路

$$i_2=\frac{2\Omega\times(-i_2)}{1\Omega}-\frac{u_1-2\Omega\times(-i_2)}{1\Omega}$$

u_1=-5i_2　　**g_{21}=-0.2s**

6-1（a）

$$g_{12}=\left.\frac{i_1(t)}{u_2(t)}\right|_{u_1(t)=0}$$



u_1=0 -> u_1短路

$$i_1=\frac{1\Omega\times(-i_1)}{1\Omega}-\frac{u_2-1\Omega\times(-i_1)}{2\Omega}$$

u_2=-5i_1

g_{12}=-0.2s

$$g_{22}=\left.\frac{i_2(t)}{u_2(t)}\right|_{u_1(t)=0}$$

u_2=i_2 X (2Ω +((1*1)/(1+1))Ω)

u_2=2.5i_2

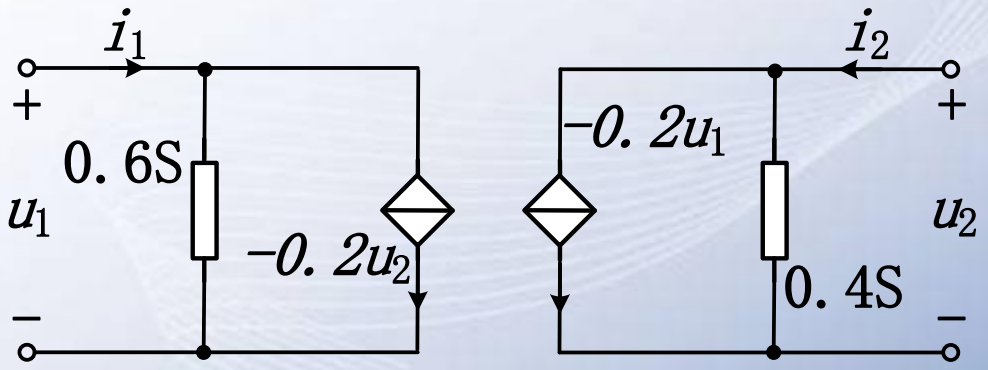
g_{22}=0.4s

6-1（a）

电导等效方程（g方程）

$$i_1(t) = 0.6u_1(t) - 0.2u_2(t)$$
$$i_2(t) = -0.2u_1(t) + 0.4u_2(t)$$

电导等效电路图



6-1（a）

P85页 **$G=R^{-1}$** **$R=G^{-1}$**

$$R^{-1}=\frac{\mathrm{R}^{*}}{|R|}=\frac{\begin{pmatrix} r_{22} & -r_{12} \\ -r_{21} & r_{11} \end{pmatrix}}{\begin{vmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{vmatrix}}=\frac{\begin{pmatrix} r_{22} & -r_{12} \\ -r_{21} & r_{11} \end{pmatrix}}{r_{11}r_{22}-r_{12}r_{21}}$$

6-1 求图示双口网络的电阻参数和电导参数

$$r_{11}=\left.\frac{u_1}{i_1}\right|_{i_2=0}=2\ \Omega \qquad r_{12}=\left.\frac{u_1}{i_2}\right|_{i_1=0}=1\ \Omega$$

$$r_{21}=\left.\frac{u_2}{i_1}\right|_{i_2=0}=1\ \Omega \qquad r_{22}=\left.\frac{u_2}{i_2}\right|_{i_1=0}=3\ \Omega$$

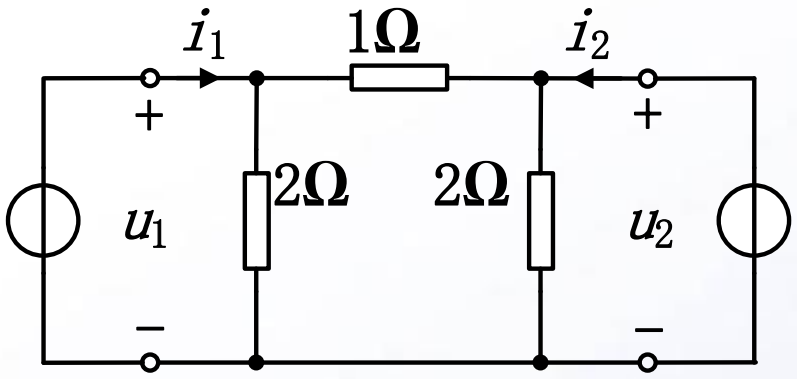
再利用电阻参数矩阵与电导参数矩阵的关系，可以求得四个电导参数

$$\boldsymbol{G}=\boldsymbol{R}^{-1}=\frac{\begin{pmatrix}3&-1\\-1&2\end{pmatrix}}{\begin{vmatrix}2&1\\1&3\end{vmatrix}}\mathrm{S}=\frac{\begin{pmatrix}3&-1\\-1&2\end{pmatrix}}{5}\mathrm{S}=\begin{pmatrix}0.6&-0.2\\-0.2&0.4\end{pmatrix}\mathrm{S}$$

$$g_{11}=0.6\ \mathrm{S} \qquad g_{12}=-0.2\ \mathrm{S}$$

$$g_{21}=-0.2\ \mathrm{S} \qquad g_{22}=0.4\ \mathrm{S}$$

6-1 求图示双口网络的电阻参数和电导参数，并求等效电路

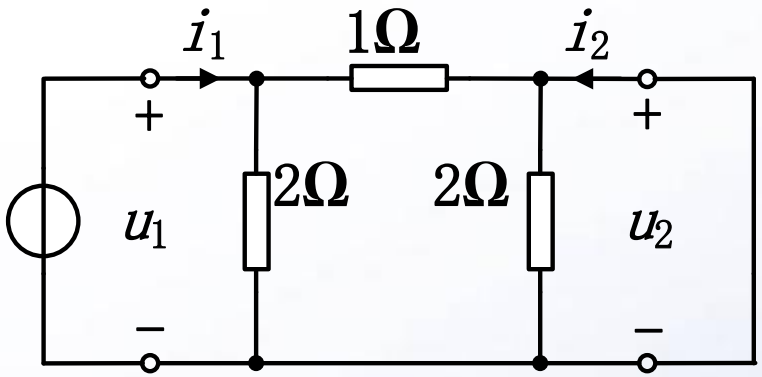


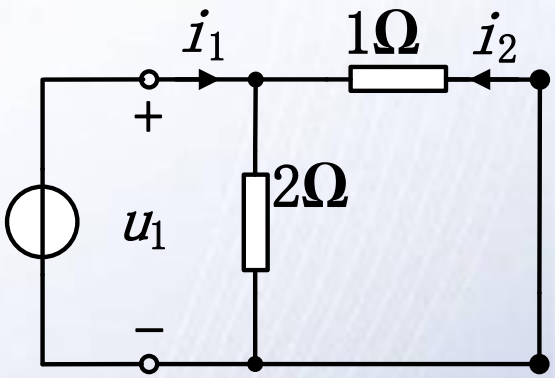
电导方程（g方程）

$$i_1(t) = g_{11}u_1(t) + g_{12}u_2(t)$$
$$i_2(t) = g_{21}u_1(t) + g_{22}u_2(t)$$

6-1

$$g_{11}=\left.\frac{i_1(t)}{u_1(t)}\right|_{u_2(t)=0}$$





$$u_1=\frac{1\Omega\times 2\Omega}{1\Omega+2\Omega}\times i_1$$

g_{11}=1.5s

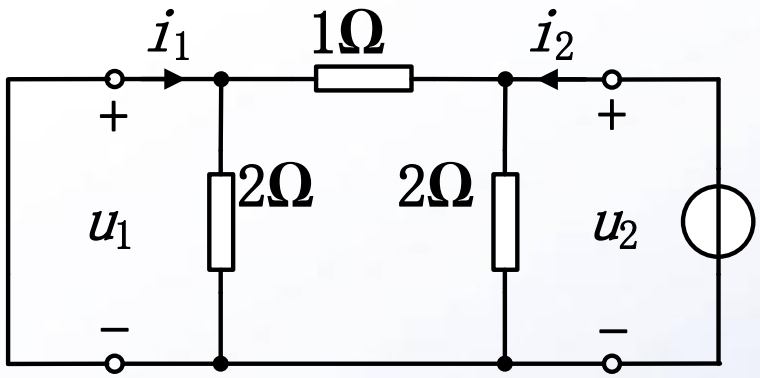
$$g_{21}=\left.\frac{i_2(t)}{u_1(t)}\right|_{u_2(t)=0}$$

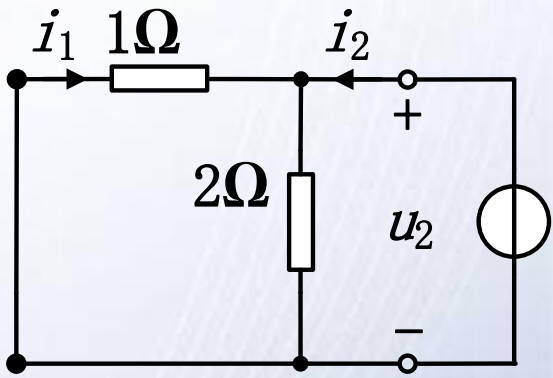
$$u_1=1\Omega\times(-i_2)$$

g_{21}=-1s

6-1

$$g_{12}=\left.\frac{i_1(t)}{u_2(t)}\right|_{u_1(t)=0}$$





$$u_2=1\Omega\times(-i_1)$$

g_{12}=-1s

$$g_{22}=\left.\frac{i_2(t)}{u_2(t)}\right|_{u_1(t)=0}$$

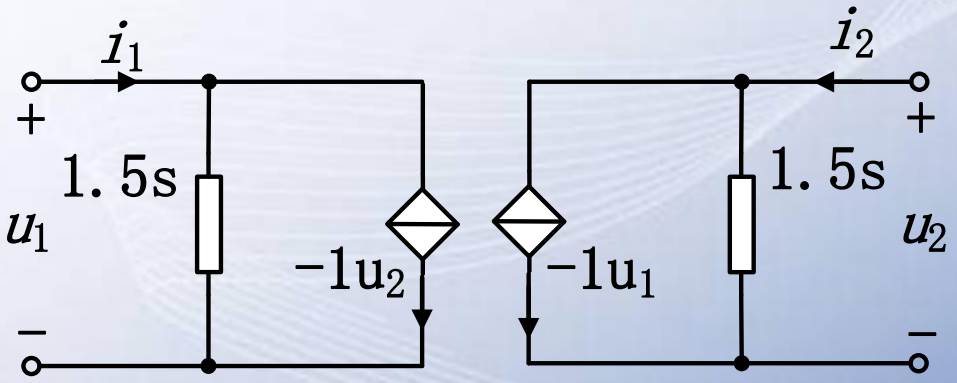
$$u_2=\frac{1\Omega\times 2\Omega}{1\Omega+2\Omega}\times i_2$$

g_{22}=1.5s

电导等效方程（g方程）

$$i_1(t)=1.5u_1(t)-u_2(t)$$
$$i_2(t)=-u_1(t)+1.5u_2(t)$$

电导等效电路图



6-1 求图示双口网络的电阻参数和电导参数

$$g_{11}=\left.\frac{i_1}{u_1}\right|_{u_2=0}=1.5\ \mathrm{S} \qquad g_{12}=\left.\frac{i_1}{u_2}\right|_{u_1=0}=-1\ \mathrm{S}$$

$$g_{21}=\left.\frac{i_2}{u_1}\right|_{u_2=0}=-1\ \mathrm{S} \qquad g_{22}=\left.\frac{i_2}{u_2}\right|_{u_1=0}=1.5\ \mathrm{S}$$

再利用电阻参数矩阵与电导参数矩阵的关系，可以求得四个电阻参数

$$\boldsymbol{R}=\boldsymbol{G}^{-1}=\frac{\begin{pmatrix}1.5 & 1\\ 1 & 1.5\end{pmatrix}}{\begin{vmatrix}1.5 & -1\\ -1 & 1.5\end{vmatrix}}\Omega=\frac{\begin{pmatrix}1.5 & 1\\ 1 & 1.5\end{pmatrix}}{1.25}\Omega=\begin{pmatrix}1.2 & 0.8\\ 0.8 & 1.2\end{pmatrix}\Omega$$

$$r_{11}=1.2\ \Omega \qquad r_{12}=0.8\ \Omega$$

$$r_{21}=0.8\ \Omega \qquad r_{22}=1.2\ \Omega$$

电阻等效方程：

$$u_1(t) = 1.2i_1(t) + 0.8i_2(t)$$
$$u_2(t) = 0.8i_1(t) + 1.2i_2(t)$$

电阻等效电路图