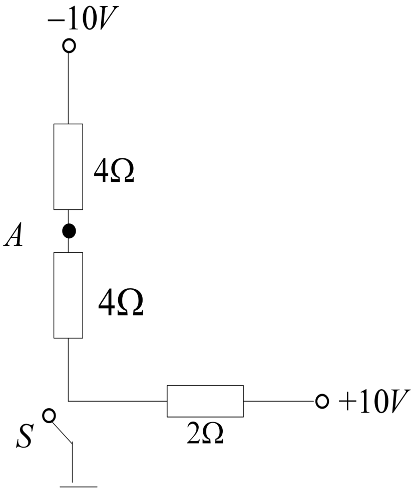
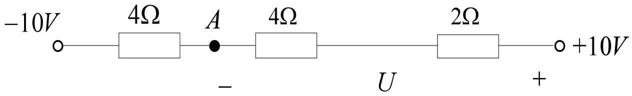
课时一 练习题

1. 求当 S 打开和闭合时 A 点的电位

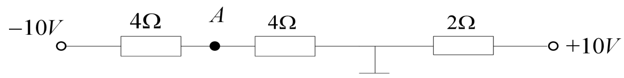


解：S 打开



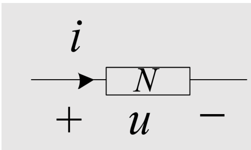
$$U_A = 10 - V_A = \frac{4+2}{4+2+4}\left(10-(-10)\right) \Rightarrow U_A = -2V$$

S 闭合



$$V_A = \frac{4}{4+4}(-10) = -5V$$

2. 如图电路 N，电压电流参考方向如图：

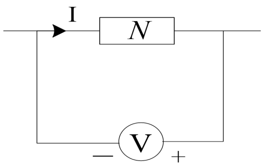


若 $i = 1A, u = 3V$，则 N 吸收功率_____；

若 $i = -1A, u = 4V$，则 N 产生功率_____。

解：u 与 i 关联，若 $i = 1A, u = 3V$，则 $P_{吸收} = ui = 3W$；若 $i = -1A, u = 4V$，则 $P_{产生} = -ui = 4W$。

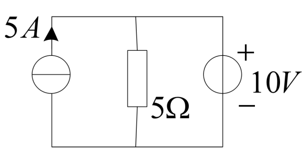
3. 如图一般直流电路 N 电流参考方向。忽略电压表内阻对测试电路的影响。$V = 5V$。N 吸收功率为 $10W$，则 $I = \underline{-2A}$



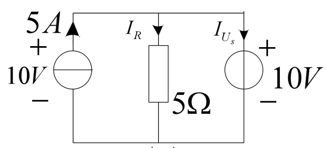
解析：I 与 U 为非并联方向。

$\therefore P_{吸} = -UI = 10W \quad \therefore I = -2A$

4. 如图 (a) 判断下列电路中的电压源和电流源是产生还是消耗功率，产生或消耗多少？



(a)



(b)

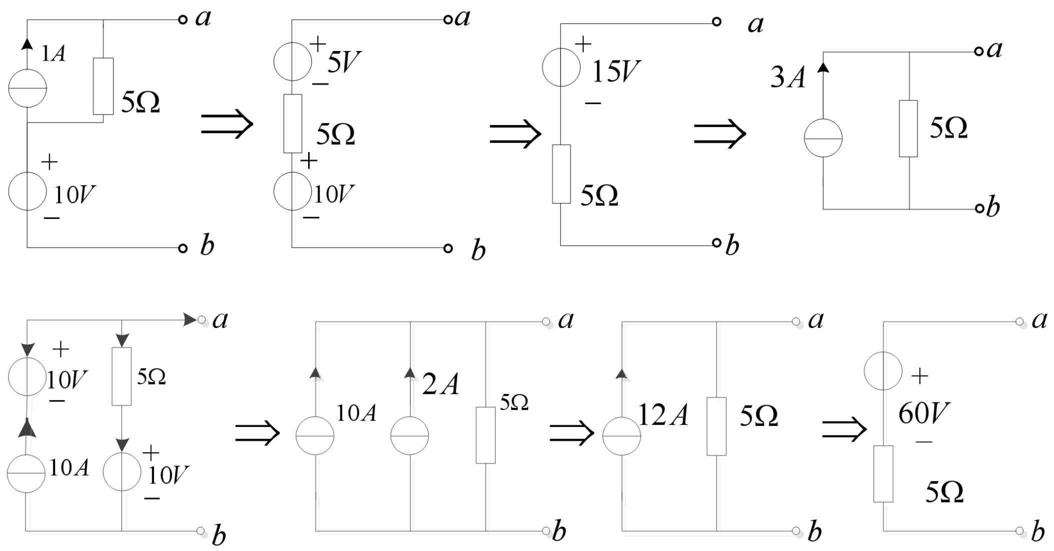
解：①标方向如 (b)

②电流源产生功率 $P_{产生} = UI = 10 \times 5 = 50W$　　通过电阻的电流：$I_R = \frac{U}{R} = \frac{10}{5} = 2A$

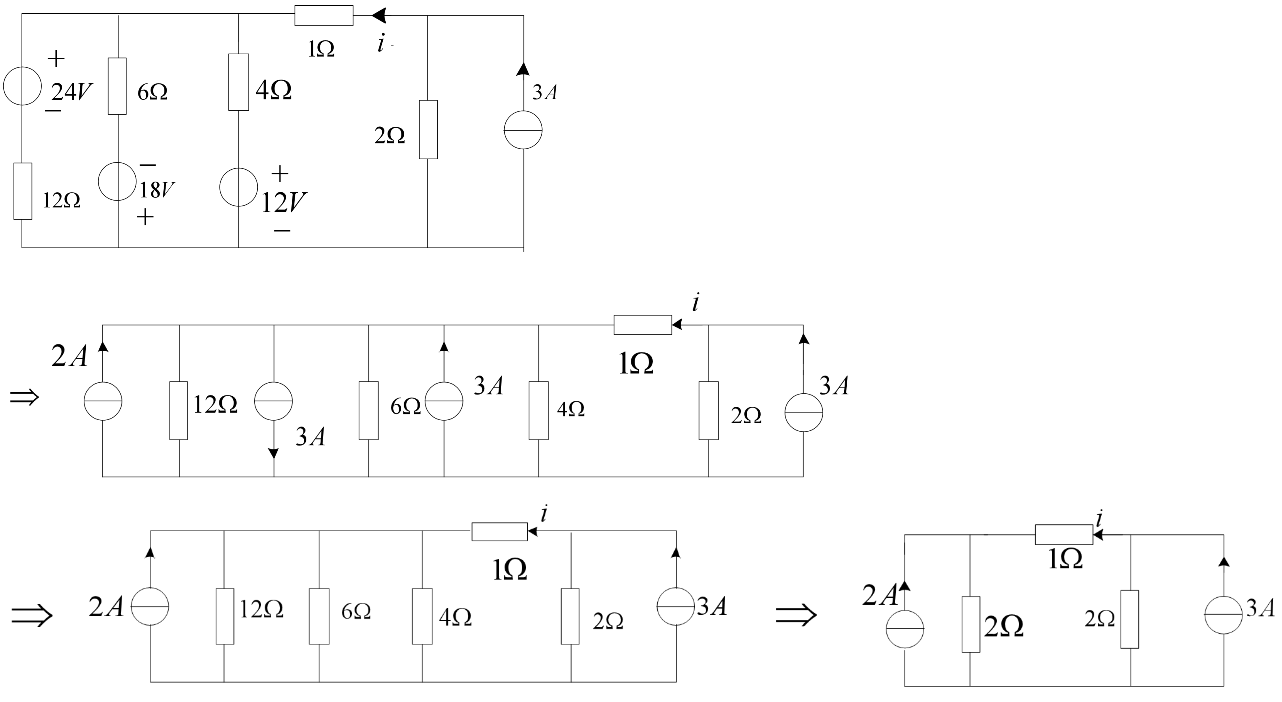
通过电压源的电流：$I_{U_s} = I_s - I_R = 3A$　　电压源消耗功率：$P_{U_s} = I_{U_s} \times U_s = 3 \times 10 = 30W$

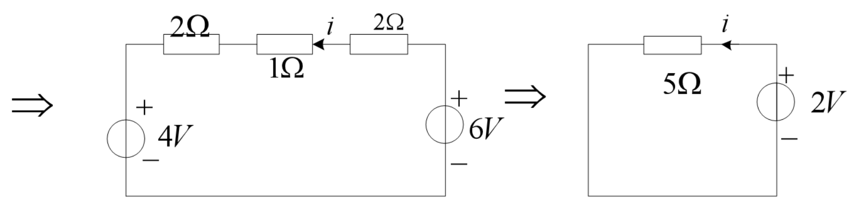
课时二　练习题

1. 电路图如下，对 ab 端化简为最简的等效电压源形式和等效电流源形式



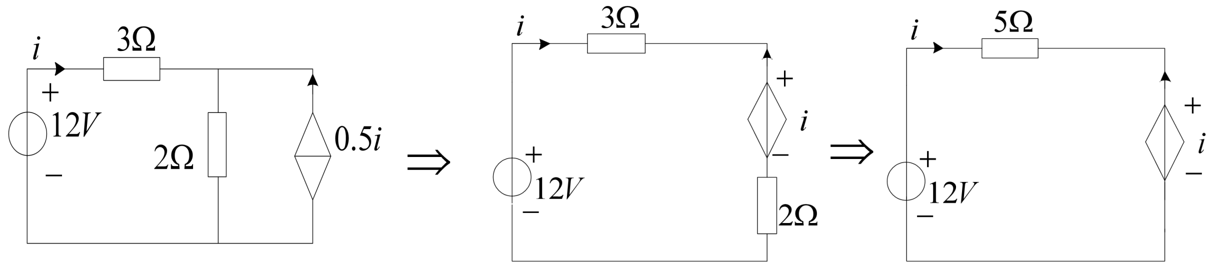
2. 求图示电路中的电流 i





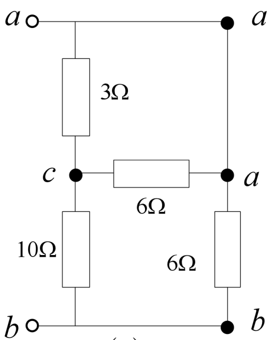
$$i=\frac{2V}{5\Omega}=0.4A$$

3. 用等效电源交换法求下列电路 i

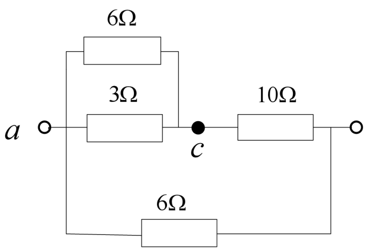


解：$12-i=5i \quad \Rightarrow i=2A$

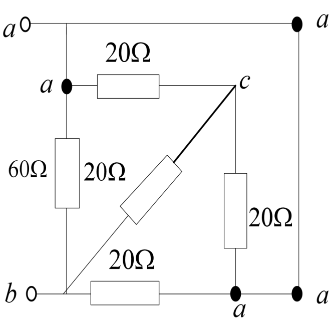
4. 求下列电路 ab 端等效电阻



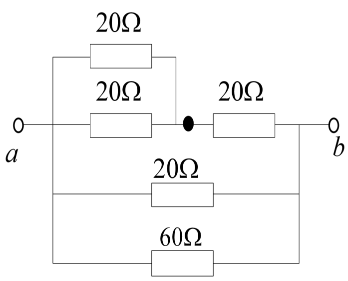
(a)



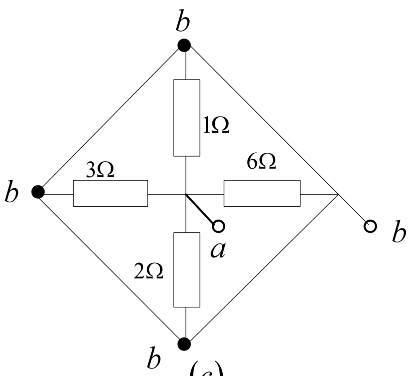
$$R_{eq}=(6\Omega//3\Omega+10\Omega)//6\Omega$$
$$=(\frac{6\Omega\times3\Omega}{6\Omega+3\Omega}+10\Omega)//6\Omega$$
$$=(2\Omega+10\Omega)//6\Omega$$
$$=12\Omega//6\Omega=\frac{12\times6}{12+6}\Omega=4\Omega$$



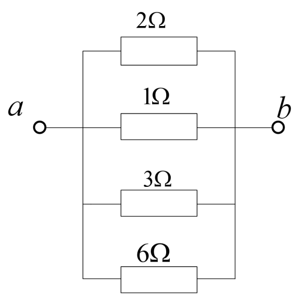
(b)



$$R_{eq}=\left(20\Omega//20\Omega+20\Omega\right)//20\Omega//60\Omega$$
$$=\left(\frac{20\times20}{20+20}\Omega+20\Omega\right)//20\Omega//60\Omega$$
$$=\left(10\Omega+20\Omega\right)//20\Omega//60\Omega$$
$$=30\Omega//20\Omega//60\Omega=10\Omega$$



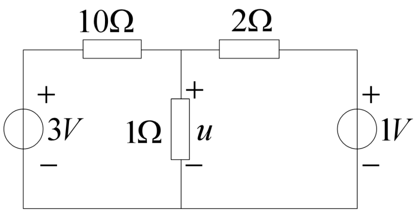
(c)



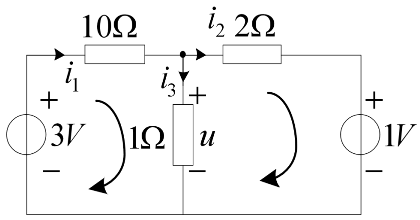
$$R_{eq}=2\Omega//1\Omega//3\Omega//6\Omega$$
$$=\frac{2\Omega\times1\Omega}{2\Omega+1\Omega}//\frac{3\Omega\times6\Omega}{3\Omega+6\Omega}=\frac{2}{3}\Omega//2\Omega$$
$$=\frac{\frac{2}{3}\Omega\times2\Omega}{\frac{2}{3}\Omega+2\Omega}=\frac{1}{2}\Omega$$

课时三　练习题

1. 如下电路图(a)下面电路的电压u



(a)

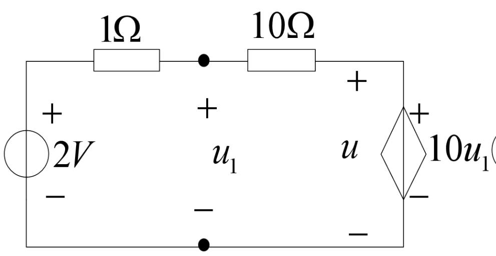


(b)

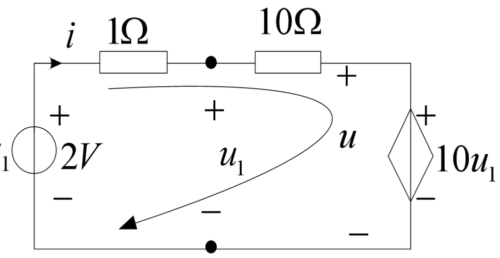
①确定电流方向如(b)

② $\begin{cases} i_1 = i_2 + i_3 \\ 3 = 10i_1 + i_3 \\ i_3 = 2i_2 + 1 \end{cases}$ $\quad \therefore i_1 = \frac{1}{4}A \quad i_2 = -\frac{1}{4}A \quad i_3 = \frac{1}{2}A \quad \quad \therefore U = i_3 = \frac{1}{2}V$

2. 求 a 图电路电压u



(a)



(b)

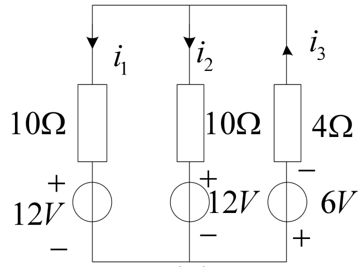
解：①确定电流方向如(b)

② $2 = 11i + 10u_1 \quad u_1 = 10i + 10u_1$

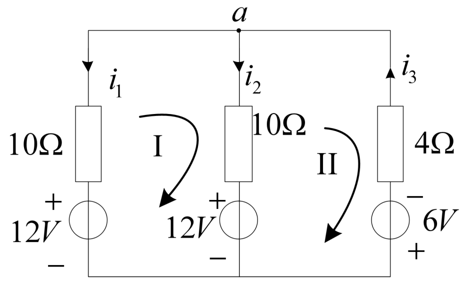
$\Rightarrow i = -18A \quad u_1 = 20V \quad \Rightarrow u = 10u_1 = 200V$

课时四　练习题

1. 如下图(a)用支路电流法求i_1,i_2,i_3



(a)



(b)

解：①确定节点、支路、回路，如图(b)

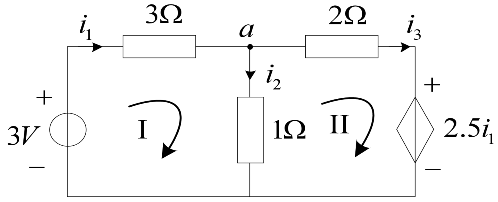
②在a点，由KCL得：$i_3 = i_1 + i_2$

回路I：$10i_2+12-12-10i_1 = 0$

回路II：$-4i_3-6-12-10i_2 = 0$

计算得：$i_1 = -1A \quad i_2 = -1A \quad i_3 = -2A$

2. 用支路法求各支路电流



解:①确定节点、支路、回路，如图

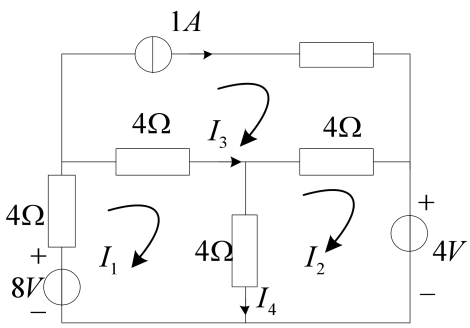
②在a点，由KCL得$i_1 = i_2 + i_3$

在回路I：$3i_1+i_2-3 = 0$

在回路II：$2i_3+2.5i_1-i_2 = 0$

计算得：$i_1 = \frac{2}{3}A \quad i_2 = 1A \quad i_3 = -\frac{1}{3}A$

3. 用回路法求I_4



解：确定回路个数和绕行方向，如图

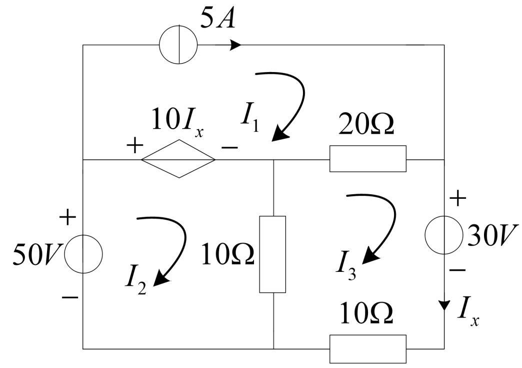
回路I:$12I_1-4I_2-4I_3 = 8$

回路II:$8I_2-4I_1-4I_3 = -4$

对回路III:$I_3 = 1A$

解得：$I_1 = 1.2A \quad I_2 = 0.6A \quad I_3 = 1A \qquad \Rightarrow I_4 = I_1 - I_2 = 0.6A$

4. 用回路法求 I_x



解：确定回路个数和绕行方向，如图

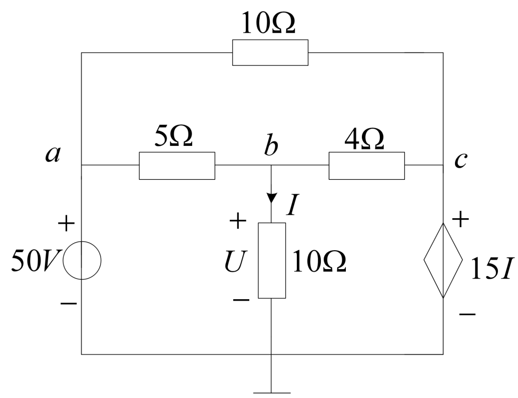
回路 I : $I_1 = 5A$

回路 II : $10I_2 - 10I_3 = 50 - 10I_x$

对回路 III : $40I_3 - 20I_1 - 10I_2 = -30$

解得：$I_1 = 5A \quad I_2 = 5A \quad I_3 = 3A \qquad \Rightarrow I_3 = I_x = 3A$

5. 用节点法求下图中电路的电压 U



解：确定节点个数及参考点，如图

节点 $a: U_a = 50V$

节点 $b: \left(\frac{1}{5}+\frac{1}{4}+\frac{1}{10}\right)U_b - \frac{1}{5}U_a - \frac{1}{4}U_c = 0$

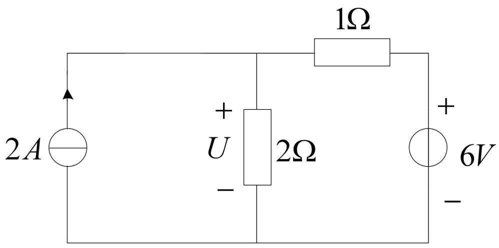
节点 $c: U_c = 15I$

补充一个方程：$I = \frac{U_b}{10}$

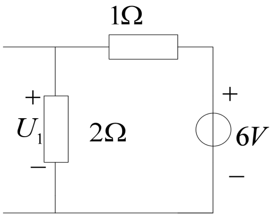
解得：$U_a = 50V \quad U_b = \frac{400}{7}V \quad U_c = \frac{600}{7}V \qquad \Rightarrow U = U_b = \frac{400}{7}V$

课时五　练习题

1. 如下图用叠加定理求U

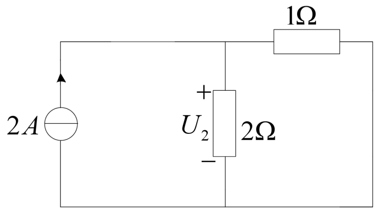


解：①电压源单独作用等效电路



$$U_1 = \frac{2\Omega}{1\Omega + 2\Omega} \times 6V = 4V$$

②电流源单独作用等效电路



$$U_2 = 2A \times (2\Omega // 1\Omega) = \frac{4}{3}V$$

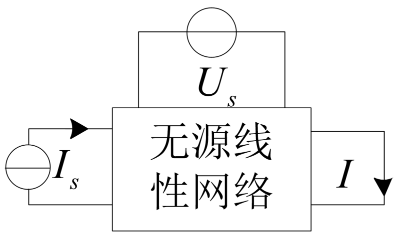
③叠加定理$\therefore U = U_1 + U_2 = \frac{16}{3}V$

2. 封装好的电路图如图所示，已知下列实验数据；

当$U_s = 1V, I_s = 1A$时，响应$I = 2A$；

当$U_s = 1V, I_s = 2A$时，响应$I = 1A$；

当$U_s = 1V, I_s = 5A$时，响应I等于多少？



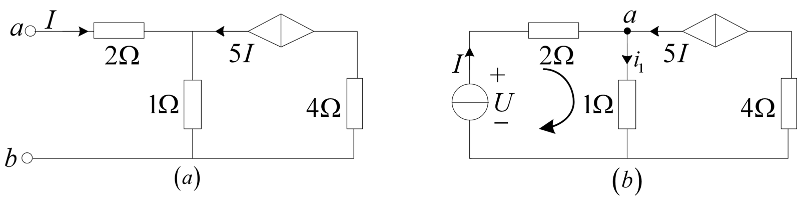
解：由齐次和叠加定理得

$$I = k_1 U_s + k_2 I_s$$

$$\therefore \begin{cases} k_1 + k_2 = 2 \\ k_1 + 2k_2 = 1 \end{cases} \Rightarrow k_1 = 3 \quad k_2 = -1 \qquad \Rightarrow I = 3U_s - I_s$$

当U_s=1V　$I_s = 5A$　　$\Rightarrow I = 3 \times 1 - 5 = -2A$

3. 如图(a)所示电路$a-b$端口输入电阻。

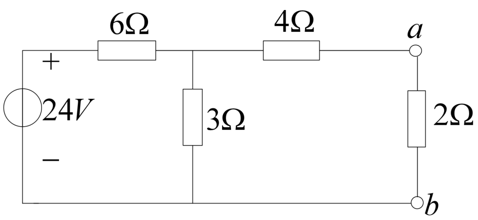


解：外加电流源等效电路如(b)

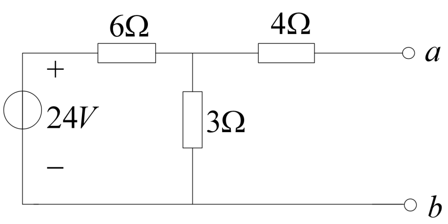
在节点a：$i_1 = I + 5I = 6I$

由 KVL 得：$U = 2I + i_1 = 8I$　　$\therefore R_{eq} = \dfrac{U}{I} = 8\Omega$

4. 电路如图，求$a-b$端左侧电路的戴维南等效电路，并求负载$R = 2\Omega$上的功率

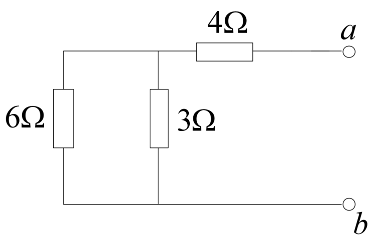


解：①求开路电压等效电路



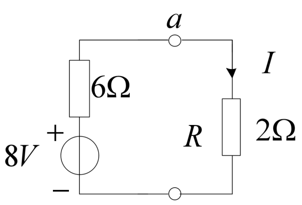
$$U_{OC} = \frac{3}{6+3} \times 24 = 8V$$

②独立源置零等效电路



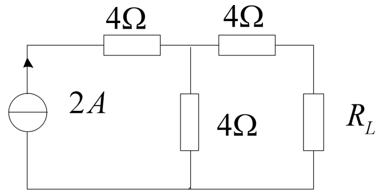
$$R_0 = 4\Omega + 6\Omega // 3\Omega = 4\Omega + \frac{6\Omega \times 3\Omega}{6\Omega + 3\Omega} = 4\Omega + 2\Omega = 6\Omega$$

③等效电路

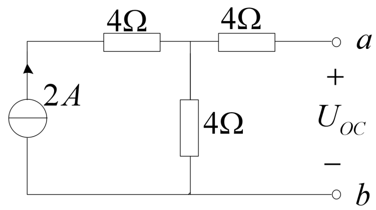


通过R的电流 $I = \dfrac{8}{6+R} = \dfrac{8}{6+2} = 1A$　　$\Rightarrow P = I^2R = 2W$

5. 如图电路负载 R_L 为何值时其上获得最大功率？最大功率是多少？

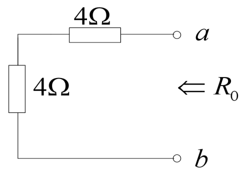


解：①求开路电压等效电路



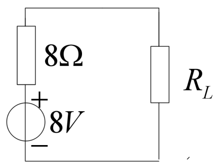
$$\therefore U_{OC} = 2A \times 4\Omega = 8V$$

②独立源置零等效电阻等效电路



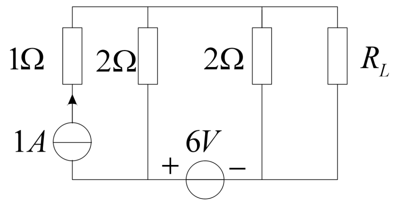
$$\therefore R_0 = 4\Omega + 4\Omega = 8\Omega$$

③等效电阻如下

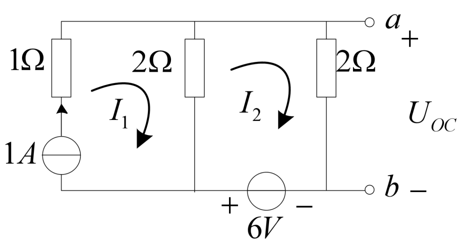


$$\therefore R_L = R_0 = 8\Omega \quad P_{L\max} = \frac{U_{OC}^{\ 2}}{4R_L} = 2W$$

6. 下图电路，R_L 为何值时其上获得最大功率？最大功率是多少？



解：①求开路电压等效电路

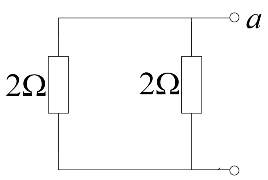


用回路法

$$\begin{cases} I_1 = 1A \\ 4I_2 - 2I_1 = 6V \end{cases} \Rightarrow I_2 = 2A$$

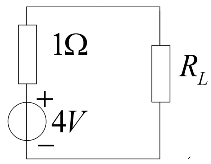
$$U_{OC} = 2\Omega \times I_2 = 4V$$

②独立源置零等效电阻等效电路



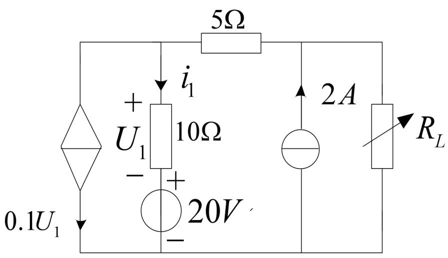
$\Rightarrow R_0 = 1\Omega$

③等效电路如下

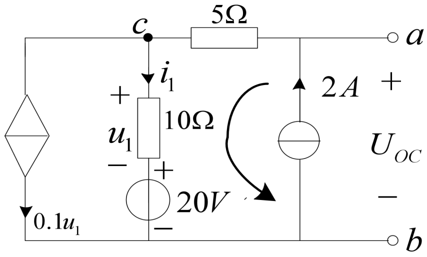


$\therefore R_L = R_0 = 1\Omega \quad P_{L\max} = \dfrac{{U_{OC}}^2}{4R_L} = 4W$

7. 如图所示电路，R_L 可任意改变，问 R_L 等于多大时其上获得最大功率？



解：①求开路电压等效电路

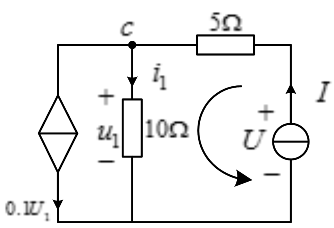


在节点 c：$i_1 = 2 - 0.1u_1$

$u_1 = 10i_1 = 10(2 - 0.1u_1) \Rightarrow u_1 = 5I$

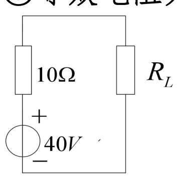
在回路中：$U_{OC} = 5\Omega \times 2A + u_1 + 20V = 40V$

②独立源置零等效电阻等效电路



在回路中：$U = 5I + u_1 = 10I \therefore R_0 = 10\Omega$

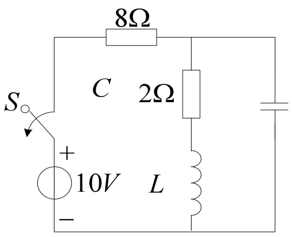
③等效电阻如下



$\therefore R_L = R_0 = 10\Omega \quad P_{L\max} = \dfrac{{U_{OC}}^2}{4R_L} = 40W$

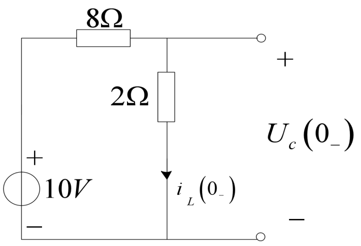
课时六　练习题

1. 如下(a)图电路$t=0$时，开关S打开，求$i_L(0_+)$、$u_L(0_+)$和$u_C(0_+)$



(a)

解：①$t=0^-$等效电路

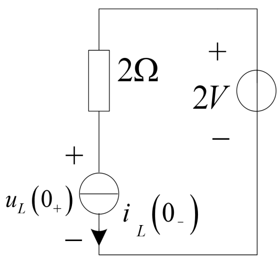


$$i_L(0_-)=\frac{10V}{8\Omega+2\Omega}=1A$$

$$u_C(0_-)=i_L(0_-)\times 2\Omega=2V$$

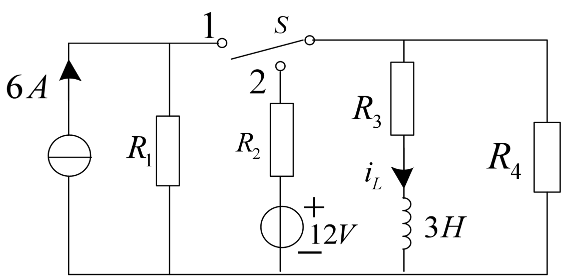
②由换路定理得：　$i_L(0_+)=i_L(0_-)=1A$　　$u_C(0_+)=u_C(0_-)=2V$

③$t=0_+$等效电路



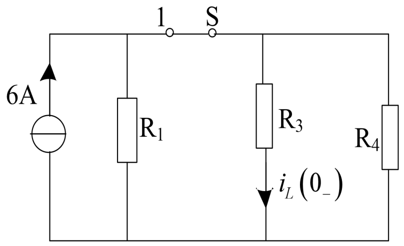
$$\therefore u_L(0_+)=2V-2\Omega\times i_L(0_+)=0V$$

2. 如(b)图所示电路，$R_1=6\Omega$，$R_2=R_4=6\Omega$，$R_3=3\Omega$，在$t<0$时，开关S由"1"闭合到"2"。求$t\geq 0$时的$i_L(t)$。



(b)

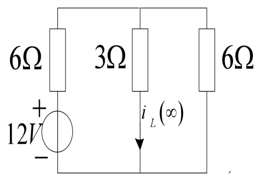
解：①$t=0^{-}$ 等效电路



$$i_L(0_-)=\frac{6\Omega//6\Omega}{6\Omega//6\Omega+3\Omega}\times 6A=3A$$

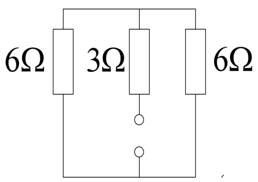
②由换路定理得： $i_L(0_+)=i_L(0_-)=3A$

③$t=\infty$ 等效电路



$$i_L(\infty)=\frac{12V}{6\Omega+3\Omega//6\Omega}\times\frac{6\Omega}{3\Omega+6\Omega}=1A$$

④求解时常数τ



$$\therefore \tau=\frac{L}{R}=\frac{3H}{3\Omega+6\Omega//6\Omega}=\frac{1}{2}$$

⑤代入三要素公式：$i_L(t)=\left[i_L(0_+)-i_L(\infty)\right]e^{-\frac{t}{\tau}}+i_L(\infty)=(3-1)e^{-2t}+1=2e^{-2t}+1$

课时七　练习题

1. 已知$\dot{U}_1=60\angle 0°,\dot{U}_2=60\angle 60°$

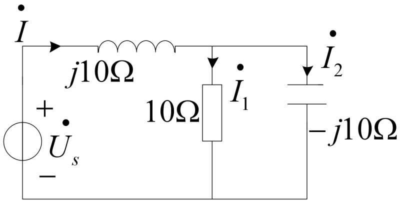
（1）写出u_1、u_2的瞬时表达式

（2）令$u_3=u_1+u_2$，求出u_3的瞬时表达式

解：（1）$u_1=60\sqrt{2}\cos(\omega t)V$　$u_2=60\sqrt{2}\cos(\omega t+60^{\circ})V$ （题目中没给角频率假设为ω）

（2）$\dot{u}_3=\dot{u}_1+\dot{u}_2=60\sqrt{3}\angle 30^{\circ}\ \therefore u_3(t)=60\sqrt{6}\cos(\omega t+30^{\circ})V$

2. 如下图(a)电路，设$\dot{U}_s=100\angle 0^\circ V$，求$\dot{I},\dot{I}_1,\dot{I}_2$



(a)

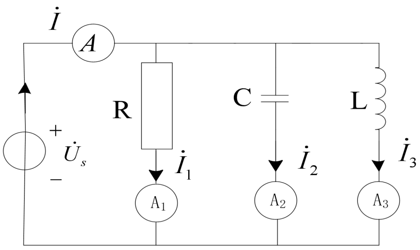
解：$z_{总}=j10+[10//(-j10)]=j10+\dfrac{10\times(-j10)}{10-j10}=5+j5\,(\Omega)=5\sqrt{2}\angle 45^\circ\,(\Omega)$

$$\therefore \dot{I}=\frac{\dot{U}_s}{z_{总}}=\frac{100\angle 0^\circ V}{5\sqrt{2}\angle 45^\circ\Omega}=10\sqrt{2}\angle -45^\circ A$$

$$\dot{I}_1=\frac{-j10}{10-j10}\dot{I}=\frac{1-j}{2}\dot{I}=\frac{\sqrt{2}}{2}\angle -45^\circ\times 10\sqrt{2}\angle -45^\circ=10\angle -90^\circ A$$

$$\dot{I}_2=\frac{10}{10-j10}\dot{I}=\frac{1+j}{2}\dot{I}=\frac{\sqrt{2}}{2}\angle 45^\circ\times 10\sqrt{2}\angle -45^\circ=10\angle 0^\circ A$$

3. 如下图(b)所示，已知电流表$A_1:5A, A_2:20A, A_3:25A$，求电流表A的读数



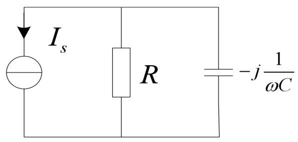
(b)

$$I=\sqrt{I_1^{\,2}+(I_2-I_3)^2}=\sqrt{5^2+(20-25)^2}=5\sqrt{2}A$$

$\therefore$ 电流表 A 的读数为 $5\sqrt{2}A$

课时八　练习题

1. 图(a)示交流电路，已知$\dot{I}_s = 2\sqrt{2}\angle 45°A$， $R = 25\Omega$，$\frac{1}{\omega C} = 25\Omega$，求负载的有功功率和无功功率



(a)

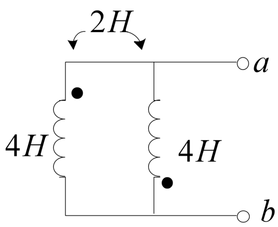
解：$z_{总} = R//-j\frac{1}{\omega C} = 25\Omega//-j25\Omega = \frac{25\times(-j25)}{25-j25}\Omega = \frac{25}{2}(1-j) = \frac{25\sqrt{2}}{2}\angle -45^\circ(\Omega)$

$$\dot{U} = \dot{I}_s \times z_{总} = 2\sqrt{2}\angle 45^\circ A \times \frac{25\sqrt{2}}{2}\angle -45^\circ\Omega = 50\angle 0^\circ V \qquad \Rightarrow \theta = \varphi_U - \varphi_I = -45^\circ$$

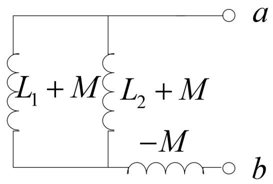
$$P = UI_s\cos\theta = 2\sqrt{2}\times 50\times\frac{\sqrt{2}}{2} = 100W \qquad Q = UI\sin\theta = 2\sqrt{2}\times 50\times\left(-\frac{\sqrt{2}}{2}\right) = -100\,\mathrm{var}$$

课时九　练习题

1. 下列电路ab端等效电感为____

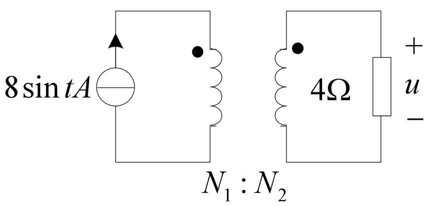


解：异名端关联可等效为

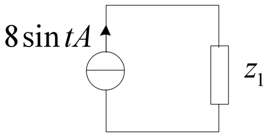


$$L_{ab} = \frac{L_1L_2 - M^2}{L_1 + L_2 + 2M} = 1H$$

2. 图示电路，理想变压器的匝数比$N_1/N_2 = 10$，则电压u为多少？



解：将电路等效到初级，如下：



$$z_1 = \left(\frac{N_1}{N_2}\right)^2 \times 4\Omega = 400\Omega$$

$\dot{I} = 4\sqrt{2}\angle 0^\circ A$　　$\therefore \dot{U}_1 = \dot{I} \times z_1 = 1600\sqrt{2}\angle 0^\circ V$

$\because \dot{U}_1 = 10\dot{U}_2$　　$\therefore \dot{U}_2 = \dfrac{\dot{U}_1}{10} = 160\sqrt{2}\angle 0^\circ V$　　$\therefore U_2 = 160\sqrt{2}V$

课时十　练习题

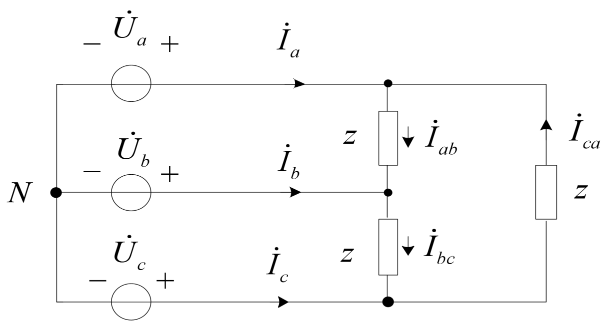
1. $Y-Y$ 形连接的三相对称电路，电源线电压为 $380V$，各相负载阻抗 $Z=6+j8\Omega$，求三相电路的总功率。

$U_l = 380V$　$\therefore U_p = 220V$　$\therefore \dot{U}_a = 220\angle 0^\circ V$

$$\therefore \dot{I}_a = \frac{\dot{U}_a}{z} = \frac{220\angle 0^\circ V}{6+j8(\Omega)} = 22\angle -53^\circ A \ \Rightarrow \theta = 0^\circ - (-53^\circ) = 53^\circ$$

$\therefore P_p = I_p U_p \cos\theta = 22\times 220\times \cos(53^\circ) \approx 2920W$　$\therefore P_{总} = 3P_a = 8760W$

2. 如下图所示 $z = 10 + j10\Omega$，电源相电压为 $220V$，求负载端的线电压、线电流、相电流和总功率



解：$\because U_p = 220V$　　$\therefore U_l = \sqrt{3}U_p = 380V$

假设 $\dot{U}_{ab} = U_l\angle 0^\circ = 380\angle 0^\circ V$

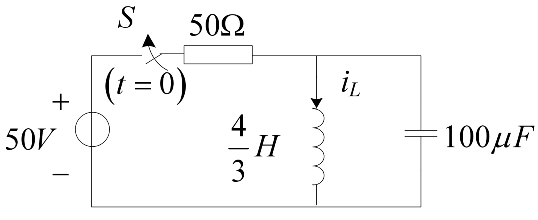
$$\therefore \dot{I}_{ab} = \frac{\dot{U}_{ab}}{z} = \frac{380\angle 0^\circ V}{10 + j10(\Omega)} = \frac{380}{10\sqrt{2}}\angle -45^\circ (A) = 26.87\angle -45^\circ (A)$$

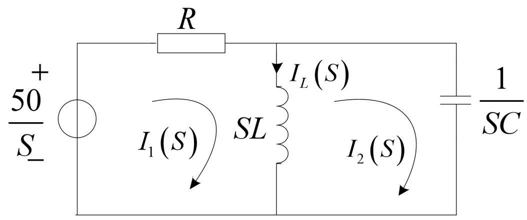
相电流 $I_p = 26.87A$　$\because I_l = \sqrt{3}I_p$　线电流 $I_l = 46.54(A)$

$\therefore P_p = 3U_p I_p \cos\theta_z == 3\times 380\times 26.87\times \cos(0-(-45^\circ)) \approx 21660W$

课时十一　练习题

1．下图(a)所示电路原处于零状态，$t=0$时合上开关S，试求电流i_L（用运算法）。





解：$i_L(0_-)=0 \qquad u_C(0_-)=0 \qquad U_s=50 \Rightarrow \dfrac{50}{S}$

画出运算电路，如图(b)，用回路法求解

$$(R+SL)I_1(S)-SLI_2(S)=\frac{50}{S}$$

$$-SLI_1(S)+\left(SL+\frac{1}{SC}\right)I_2(S)=0$$

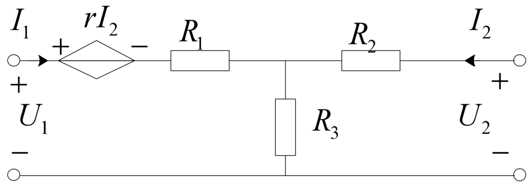
$$I_L(S)=I_1(S)-I_2(S)=\frac{50}{RLC}\times\frac{1}{S\left(S^2+\dfrac{1}{RC}S+\dfrac{1}{LC}\right)}$$

$$I_L(S)=\frac{7500}{S\left(S^2+200S+7500\right)}=\frac{7500}{S(S+50)(S+150)}=\frac{1}{S}-\frac{1.5}{S+50}+\frac{0.5}{S+150}$$

$$\therefore i_L(t)=1-1.5e^{-50t}+0.5e^{-150t}\,(A)$$

课时十二　练习题

1. 求出下列二端口的 z 参数矩阵



解：$z_{11}=\frac{U_1}{I_1}\Big|_{I_2=0}=R_1+R_3$　　$z_{12}=\frac{U_1}{I_2}\Big|_{I_1=0}=R_3+r$

$z_{21}=\frac{U_2}{I_1}\Big|_{I_2=0}=R_3$　　$z_{22}=\frac{U_2}{I_2}\Big|_{I_1=0}=R_2+R_3$

$\therefore z$ 参数矩阵 $\begin{bmatrix} R_1+R_3 & R_3+r \\ R_3 & R_2+R_3 \end{bmatrix}$

课时十三　练习题

1. 一 RLC 串联谐振电路，已知 $u_s(t)=100\cos\omega_0 t\,(mV)$，$C=400pF$，$r=1\Omega$，电路的通频带 $B=4\times10^4 rad/s$，求 L，ω_0 和 Q。

解：$Q=\frac{\omega_0 L}{r}$　　$B=\frac{\omega_0}{Q}=\frac{r}{L}$

$$\Rightarrow L=\frac{r}{B}=\frac{1}{4\times10^4}=0.025mH$$

$$\omega_0=\frac{1}{\sqrt{LC}}=\frac{1}{\sqrt{25\times10^{-6}\times400\times10^{-12}}}=10^7 rad/s$$

$$Q=\frac{\omega_0 L}{r}=\frac{10^7\times25\times10^{-6}}{1}=250$$