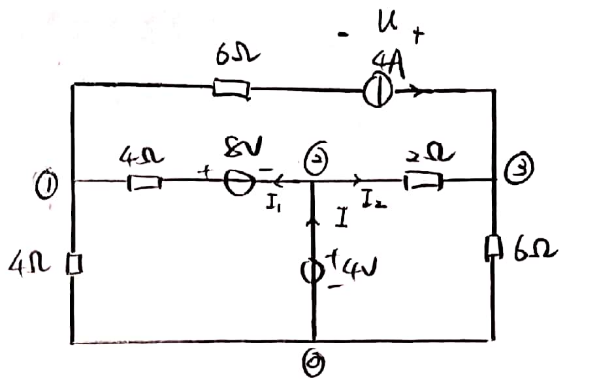
1.

解法一（节点电压法）：



列写节点电压方程

$$\begin{cases} \left(\frac{1}{4}+\frac{1}{4}\right)u_{n1}-\frac{1}{4}u_{n2}=-4+\frac{8}{4} \\ u_{n2}=4 \\ \left(\frac{1}{2}+\frac{1}{6}\right)u_{n3}-\frac{1}{2}u_{n2}=4 \end{cases}$$

$$\Rightarrow \begin{cases} u_{n1}=-2V \\ u_{n2}=4V \\ u_{n3}=9V \end{cases}$$

$$u_{n3}-u_{n1}=u-4\times6$$

$$u=35V$$

$$\therefore P_{4A}=35\times4=140W$$

$$I=I_1+I_2=\frac{u_{n2}-u_{n1}+8}{4}+\frac{u_{n2}-u_{n3}}{2}$$

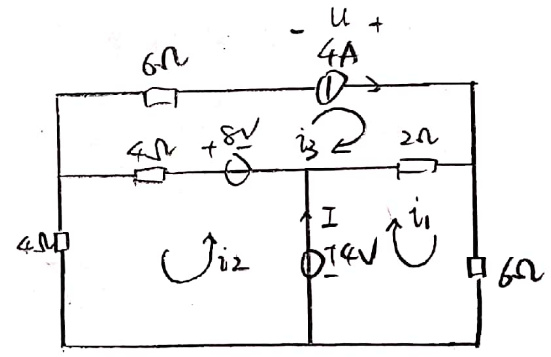
$$I=\frac{7}{2}-\frac{5}{2}=1A$$

$$\therefore P_{4V}=4\times1=4W$$

答：4A电流源发出功率140W

4V电压源发出功率4W

解法二（回路电流法）：



$$\begin{cases} (2+6)i_1-2i_3=4 \\ (4+4)i_2+4i_3=8+4 \\ i_3=4 \end{cases}$$

$$\Rightarrow \begin{cases} i_1=\frac{3}{2}A \\ i_2=-\frac{1}{2}A \\ i_3=4A \end{cases}$$

$$u=2(i_3-i_1)-8+4(i_2+i_3)+6i_3$$

$$=35V$$

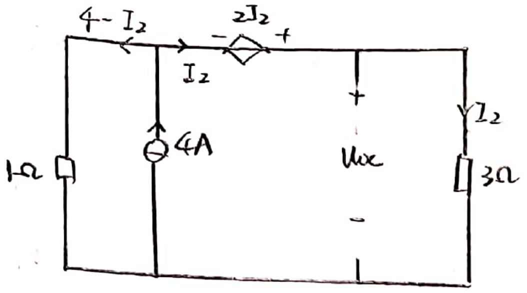
$$\therefore P_{4A}=35\times4=140W$$

$$I=i_1+i_2=1A$$

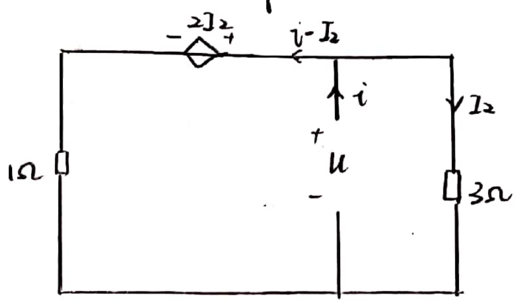
$$\therefore P_{4V}=4\times1=4W$$

2、(1) 将电阻 R 所在支路以外的网络等效为戴维南电路

先求开路电压 U_{oc}



再求等效电阻 R_{eq}



$U_{oc} = 3I_2 = 2I_2 + (4 - I_2)\times 1$

$3I_2 = I_2 + 4$

$\Rightarrow I_2 = 2A$

$\therefore U_{oc} = 3\times 2 = 6V$

$u = 3I_2 = 2I_2 + (i - I_2)\times 1$

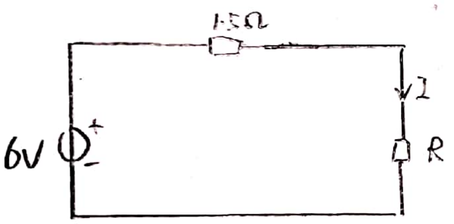
$3I_2 = I_2 + i$

$I_2 = \frac{i}{2}$

$\therefore u = 3\times\frac{i}{2} = \frac{3}{2}i$

$R_{eq} = \frac{u}{i} = 1.5\Omega$

$\therefore$ 原电路可化简为



$I = \frac{6}{R+1.5}$

$P_R = I^2\cdot R = \left(\frac{6}{R+1.5}\right)^2\cdot R = 6W$

$\Rightarrow (R-1.5)^2 = 0$

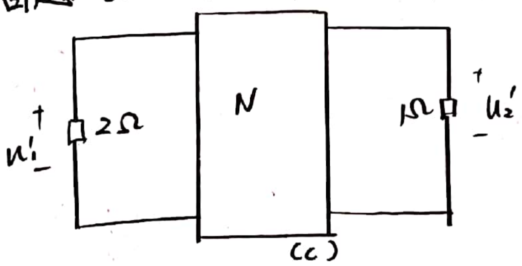
$R = 1.5\Omega$

(2) 当 $R = 1\Omega$ 时

$I = \frac{6}{1.5+1} = 2.4A$

3. 本题使用叠加定理和互易定理.

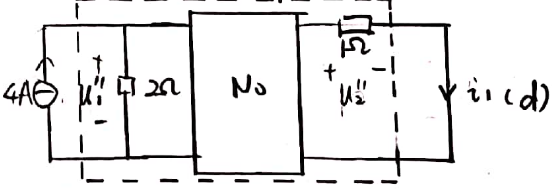
由题易知，当 N 中独立电源单独作用时



(c)

$u_1' = 2V$，$u_2' = 4V$

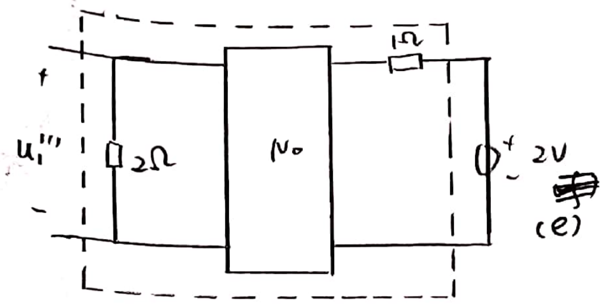
当 $I_s = 4A$ 单独作用时



(d)

$u_2'' = 8 - 4 = 4V$　$i_1 = \frac{4}{1} = 4A$

虚线部分构成互易网络



由互易定理可知

$$\frac{4}{i_1} = \frac{2}{u_1'''}$$

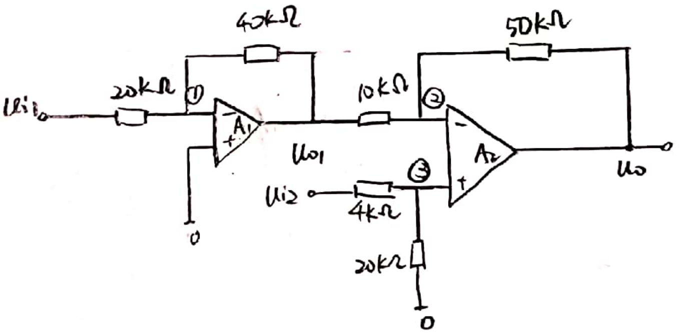
$\therefore u_1''' = 2V$

图(c)为图(b)中N独立电源单独作用

图(e)为图(b)中2V电压源单独作用

由叠加定理可知 图(b)中 $u_1 = u_1' + u_1''' = 4V$

4. 设节点1,2,3的电压分别为 u_1, u_2, u_3
由虚短特性可知 $u_1 = 0$, $u_2 = u_3$



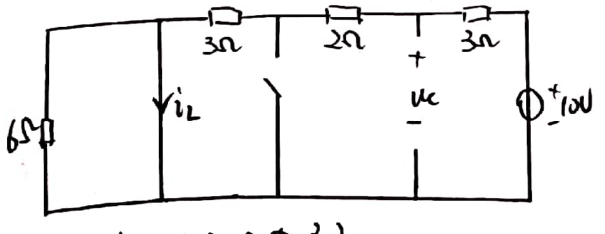
对节点1,2,3列写KCL方程

$$\begin{cases} \dfrac{u_{i1} - 0}{20K} = \dfrac{0 - u_{o1}}{40K} & ① \\ \dfrac{u_{o1} - u_2}{10k} = \dfrac{u_2 - u_o}{50k} & ② \\ \dfrac{u_{i2} - u_2}{4k} = \dfrac{u_2 - 0}{20k} & ③ \end{cases}$$

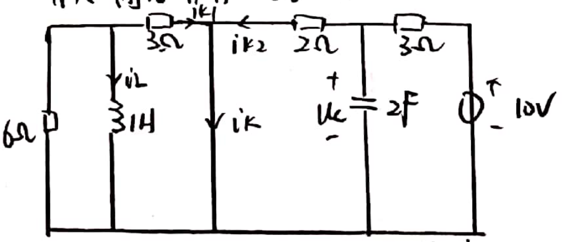
$$\Rightarrow \begin{cases} 2u_{i1} = -u_{o1} \\ 5u_{o1} + u_o = 6u_2 \\ 5u_{i2} = 6u_2 \end{cases} \Rightarrow u_{o1} = -2u_{i1}$$

$$u_o = 5u_{i2} - 5u_{o1} = 10u_{i1} + 5u_{i2}$$

5. 先求初始值，开关闭合前的电路为



开关闭合后的电路为



可以将开关闭合后的电路看成两个一阶电路

$10 = i_L \times (3+2+3)$

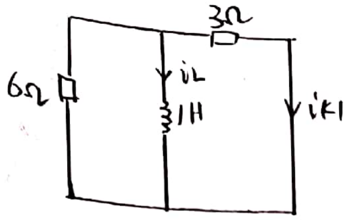
$i_L(0-) = \frac{5}{4}A$

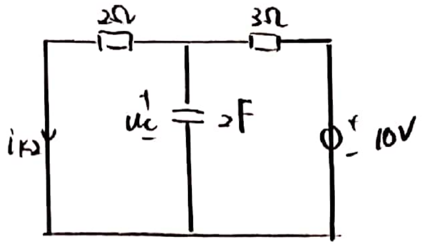
$u_c(0-) = 10 - 3i_L(0-) = \frac{25}{4}V$

开关闭合后

$i_L(0+) = i_L(0-) = \frac{5}{4}A$

$u_c(0+) = u_c(0-) = \frac{25}{4}V$





$R_{eq}' = 3 // 6 = 2\Omega$

$\tau' = \frac{1}{R_{eq}} = \frac{1}{2}\ s$

$i_L(\infty) = 0$

$i_L(t) = i_L(\infty) + [i_L(0_+) - i_L(\infty)]e^{-\frac{t}{\tau'}}$

$= \frac{5}{4}e^{-2t}\ A$

$i_{k1} = \frac{-6}{6+3} i_L(t) = -\frac{5}{6}e^{-2t}\ A$

$R_{eq}'' = 2 // 3 = \frac{6}{5}\Omega$

$\tau'' = R_{eq}'' \cdot C = \frac{12}{5}\ s$

$u_C(\infty) = \frac{10}{2+3} \times 2 = 4\ V$

$u_C(t) = u_C(\infty) + [u_C(0_+) - u_C(\infty)]e^{-\frac{t}{\tau''}}$

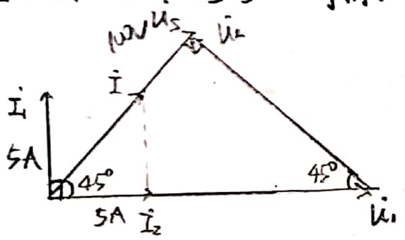
$= (4 + \frac{9}{4}e^{-\frac{5}{12}t})\ V$

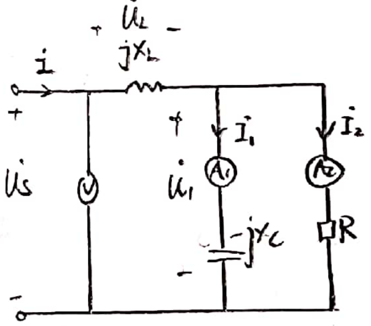
$i_{k2} = \frac{u_C(t)}{2} = (2 + \frac{9}{8}e^{-\frac{5}{12}t})\ A$

$\therefore\ i_k = i_{k1} + i_{k2} = (2 - \frac{5}{6}e^{-2t} + \frac{9}{8}e^{-\frac{5}{12}t})\ A,\quad t>0.$

6. 画相量图，以$\dot{U}_1$为参考相量

$\dot{I} = \dot{I}_1 + \dot{I}_2$，$\dot{U}_S$与$\dot{I}$同相位





由相量图可知 $\dot{I}_1 = 5\angle 90°\ A$，$\dot{I}_2 = 5\angle 0°\ A$，$\dot{U}_S = 100\angle 45°\ V$.

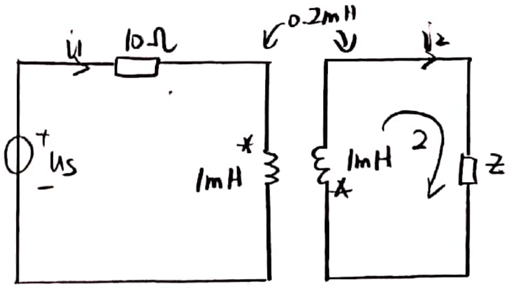
$\dot{I} = 5\sqrt{2}\angle 45°\ A \qquad \dot{U}_L = 100\angle -45°\ V \qquad \dot{U}_1 = 100\sqrt{2}\angle 0°\ V$

$R = \frac{U_1}{I_2} = \frac{100\sqrt{2}}{5} = 20\sqrt{2}\ \Omega$

$X_L = \frac{U_L}{I} = \frac{100}{5\sqrt{2}} = 10\sqrt{2}\ \Omega$

$X_C = \frac{U_{a1}}{I_1} = \frac{100\sqrt{2}}{5} = 20\sqrt{2}\ \Omega$

7. (1)



$$Z_r = \frac{(\omega M)^2}{Z_2 + j\omega L_2}$$

$$10 - j10 = \frac{(10^4 \times 0.2 \times 10^{-3})^2}{Z + j10} = \frac{4}{Z + j10}$$

$$Z = 0.2 - j9.8\ \Omega$$

$$\dot I_1 = \frac{\dot U_s}{Z_1 + j\omega L_1 + Z_r} = \frac{20\angle 0^\circ}{10 + j10 + 10 - j10} = 1\angle 0^\circ A$$

$$i_1 = \sqrt{2}\cos(10^4 t) A$$

对回路2列写KVL方程

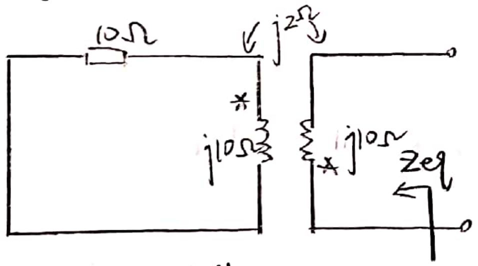
$$\dot I_2 \cdot (Z + j\omega L_2) + \dot I_1 \cdot j\omega M = 0$$

$$\dot I_2 \cdot (0.2 - j9.8 + j10) + 1\angle 0^\circ \times j2 = 0$$

$$\dot I_2 = 5\sqrt{2}\angle -135^\circ A$$

$$i_2 = 10\cos(10^4 t - 135^\circ)\ A$$

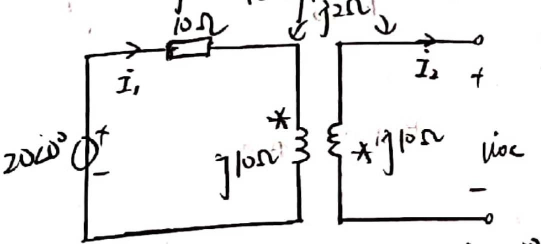
(2) 将阻抗Z之外的电路等效为戴维南电路



利用映射阻抗求Zeq

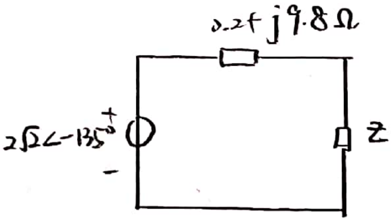
$$Z_{eq} = j\omega L_2 + Z_r' = j\omega L_2 + \frac{(\omega M)^2}{Z_1 + j\omega L_1}$$

$$= j10 + \frac{4}{10 + j10} = 0.2 + j9.8\ \Omega$$



$$\dot U_{oc} = -j\omega M \cdot \dot I_1 = -j2 \times \frac{20\angle 0^\circ}{10 + j10} = 2\sqrt{2}\angle -135^\circ V$$

∴ 电路等效为



根据最大功率传输条件，当 $Z = Z_{eq}^* = 0.2 - j9.8\Omega$ 时，Z获得最大功率

$$P_{max} = \frac{U_{oc}^2}{4Re[Z_{eq}]} = \frac{(2\sqrt{2})^2}{4 \times 0.2} = 10W$$

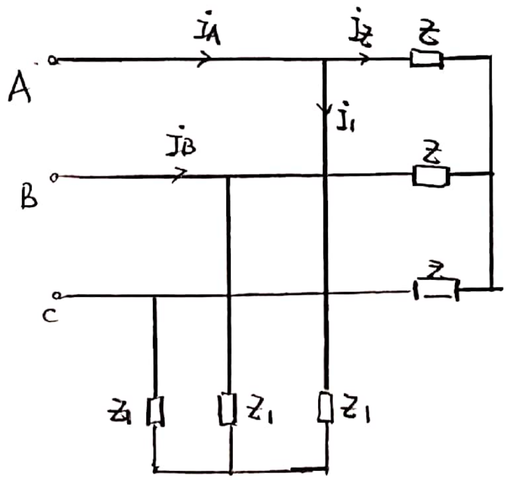
8. (1)

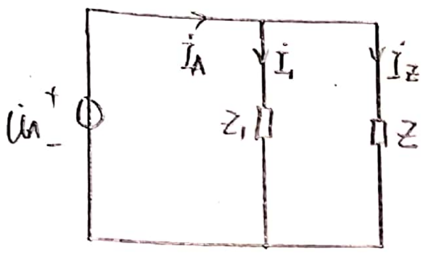
$P=\sqrt{3}U_l I_l\cos\varphi$

$I_l=\dfrac{P}{\sqrt{3}U_l\cos\varphi_Z}=\dfrac{10\times10^3}{\sqrt{3}\times380\times0.8}$

$I_l=18.99A$

$|Z|=\dfrac{U_P}{I_P}=\dfrac{U_A}{I_l}=\dfrac{380/\sqrt{3}}{18.99}=11.55\Omega$





∵ 负载为三相电动机，∴ 负载呈感性

∴ $\varphi_Z>0$　则 $\varphi_Z=\arccos0.8=36.87°$

∴ $Z=|Z|\angle\varphi_Z=11.55\angle36.87°=9.24+j6.93\ \Omega$

(2) $\dot{I}_A=\dot{I}_1+\dot{I}_Z=\dfrac{\dot{U}_A}{Z_1}+\dfrac{\dot{U}_A}{Z}=\dfrac{\frac{380}{\sqrt{3}}\angle-30°}{30-j40}+\dfrac{\frac{380}{\sqrt{3}}\angle-30°}{9.24+j6.93}$

$\dot{I}_A=19.50\angle-53.86°\ A$

$\dot{I}_B=\dot{I}_A\angle-120°=19.50\angle-173.86°A$

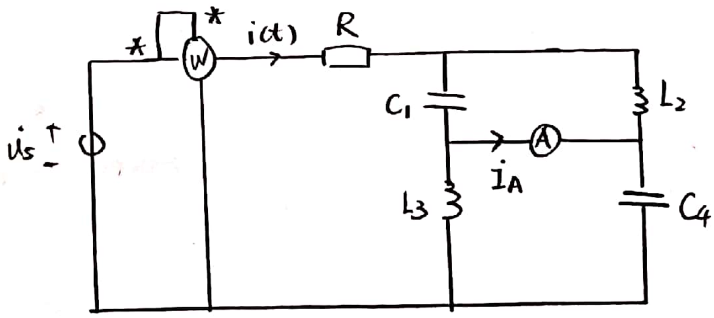
$\varphi=\varphi_{uA}-\varphi_{iA}=-30°+53.86°=23.86°$

∴ $\cos\varphi=\cos23.86°=0.91$

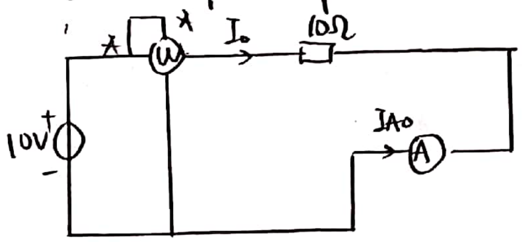
$P=P_{Z_1}+P_Z=I_1^2\times30\times3+10\times10^3$

$=\left(\dfrac{380/\sqrt{3}}{\sqrt{30^2+40^2}}\right)^2\times30\times3+10\times10^3$

$=11732.8\ W$



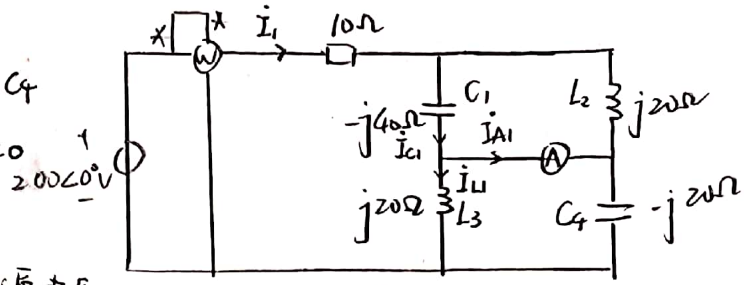
9. ①当直流源单独作用时



$I_0=\dfrac{10}{10}=1A$,　$I_{A0}=-1A$

$P_0=10\times1=10\ W$

② 当基波单独作用时



此时 L_3 与 C_4 发生并联谐振，L_3 与 C_4 的并联等效于开路，故 $\dot{I}_1 = 0$，$P_1 = 0$

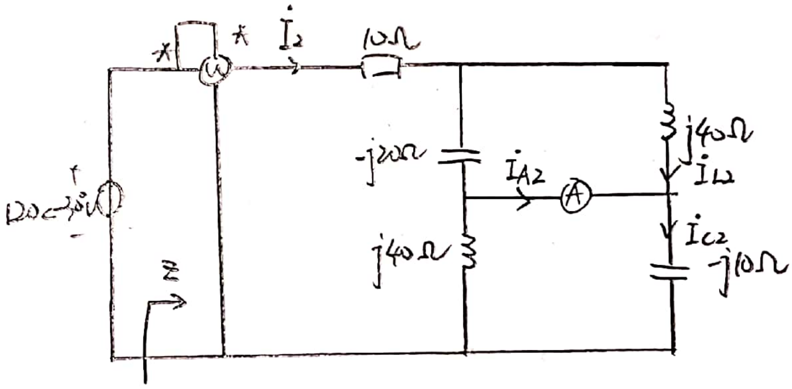
∵ C_1、L_2 并联部分的阻抗为 0，

∴ C_1、L_2 两端的电压为 0，电源电压全部施加于 L_3、C_4 并联部分。

$$\dot{I}_{L1} = \frac{200\angle 0^\circ}{j20} = 10\angle -90^\circ \text{ A}, \quad \dot{I}_{C1} = 0$$

$$\therefore \dot{I}_{A1} = -\dot{I}_{L1} = 10\angle 90^\circ \text{ A}$$

③ 当二次谐波单独作用时



$$Z = 10 + (-j20) \parallel j40 + j40 \parallel (-j10)$$

$$= 10 + \frac{-j20 \times j40}{-j20 + j40} + \frac{j40 \times (-j10)}{j40 - j10}$$

$$= 10 - j\frac{160}{3}\ \Omega$$

$$\dot{I}_2 = \frac{120\angle -30^\circ}{10 - j\frac{160}{3}} = 2.21\angle 49.38^\circ \text{ A}$$

$$i(t)_{(2)} = 2.21\sqrt{2}\sin(2\omega t + 49.38^\circ) \text{ A}$$

$$\cancel{\dot{I}_{L2} = \dot{I}_2 \times \frac{-j20}{j40 - j20}} \quad \dot{I}_{A2} = \dot{I}_{C2} - \dot{I}_{L2}$$

$$\dot{I}_{A2} = \dot{I}_2 \times \frac{j40}{j40 - j10} - \dot{I}_2 \times \frac{-j20}{j40 - j20}$$

$$= \frac{7}{3}\dot{I}_2 = 5.16\angle 49.38^\circ \text{ A}$$

$$P_2 = U_{S2} I_2 \cos\langle \widehat{\dot{U}_{S2}, \dot{I}_2} \rangle = 120 \times 2.21 \times \cos(-30^\circ - 49.38^\circ)$$

$$= 48.87 \text{ W}$$

综上所述 $i(t) = 1 + 2.21\sqrt{2}\sin(2\omega t + 49.38^\circ)$ A

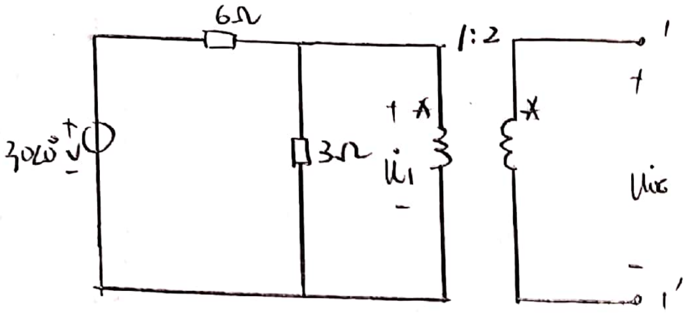
$$P = 10 + 48.87 = 58.87 \text{ W}$$

$$I_A = \sqrt{1^2 + 10^2 + 5.16^2} = 11.30 \text{ A}$$

瓦特 ~~功率~~ 表读数为 58.87W，电流表读数为 11.30 A

10.

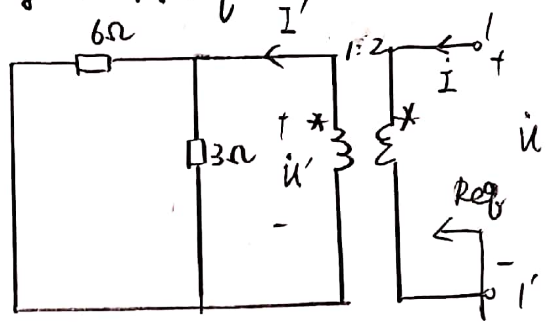
(1) 求开路电压 $\dot{U}_{oc}$



$\dot{U}_1 = 30\angle 0^\circ \times \frac{3}{6+3} = 10\angle 0^\circ\ V$

$\dot{U}_{oc} = 2\dot{U}_1 = 20\angle 0^\circ\ V$

求等效电阻 R_{eq}



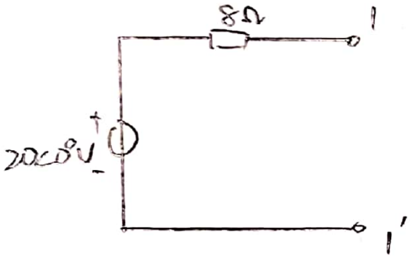
由理想变压器性质知 $\dot{U}' = \frac{1}{2}\dot{U}$, $\dot{I}' = 2\dot{I}$

$\dot{U}' = \dot{I}' \times (6//3) = 2\dot{I}'$

$\frac{1}{2}\dot{U} = 2 \times 2\dot{I}$

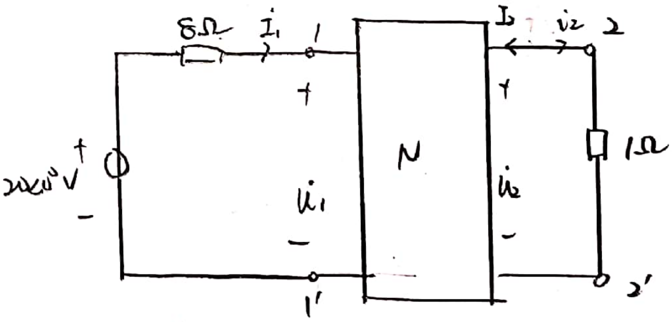
$\frac{\dot{U}}{\dot{I}} = 8\Omega$

∴ 1-1'端口左侧戴维南等效电路为



(2) 根据N的传输参数矩阵易知

$$\begin{cases} \dot{U}_1 = 2\dot{U}_2 - 8\dot{I}_2 & ① \\ \dot{I}_1 = 0.5\dot{U}_2 - 2.5\dot{I}_2 & ② \end{cases}$$



再列写KVL方程

$$\begin{cases} \dot{U}_1 = 20\angle 0^\circ - 8\dot{I}_1 & ③ \\ \dot{U}_2 = -\dot{I}_2 & ④ \end{cases}$$

由上述方程可得

$-\dot{I}_2 = \frac{10}{17}\angle 0^\circ$

∴ $i_2 = \frac{10}{17}\sqrt{2}\cos\omega t\ A$

$= 0.83\cos\omega t\ A$