北京郵電大學

Queen Mary University of London

BBC4102 A

Joint Programme Examinations 2019/20

BBC4102 Introduction to Electronic Systems

Paper A

Time allowed 2 hours

Questions 1~ 6 are for All Students.
Questions 7~ 8 are for only Classes 1~16.
Questions 9~10 are for only Classes 17~22.

1	
2	
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8	
9	
10	
Total	

Complete the information below about yourself very carefully.

QM student number											
BUPT student number											
Class number											

NOT allowed: electronic dictionaries.

INSTRUCTIONS

1. **You must not take answer books, used or unused, from the examination room.**
2. Write only in black or blue pen **and in English**.
3. Do all rough work in the answer book – **do not tear out any pages.**
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. **Read the instructions on the inside cover.**

Examiners

Hongxiang Wang, Minglun Zhang, Dong Liang, Yong Zuo, Jinnan Zhang, Hongtao Zhang, Daquan Yang

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BBC4102 2019/2020

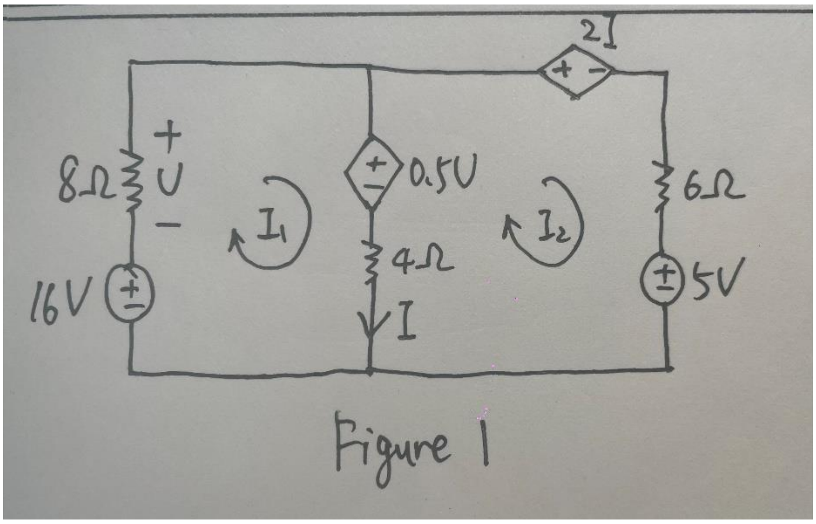
Introduction to Electronic Systems Paper A

Solutions & Analysis

By Puyuan Zheng, BUPTIS.

(写在前面的话：解答题给分点均根据解析者本人对题目的理解认为的采分点。与实际若有不同，请以实际判分为准，本解析写出的采分点仅供参考。本解析若有问题错误，欢迎批评指正。)

Question 1 (12 Marks): Use the mesh-current method to find the power dissipated by the 4Ω resistor shown in the circuit in Figure 1.



【考点 Point】

网孔电流法 Mesh-current method

电阻功率计算 Find the power of a resistor

Answer: 25W.

【解析 Analysis】

先用网孔电流法解出通过 4 欧姆电阻的电流 I，然后根据电阻功率的公式计算即可。

Solution:

By mesh-current method, we have the equations

$$\begin{cases} 16 + U - 0.5U - 4I = 0 \\ 4I + 0.5U - 2I - 6I_2 - 5 = 0 \end{cases}$$

Since $I = I_1 - I_2$ and $U = -8I_1$,we have

$$\begin{cases} 16 - 4I_1 - 4(I_1 - I_2) = 0 \\ 2(I_1 - I_2) - 4I_1 - 6I_2 - 5 = 0 \end{cases}$$

That is,

$$\begin{cases} 16 - 8I_1 + 4I_2 = 0 \\ -2I_1 - 8I_2 - 5 = 0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} I_1 = \frac{3}{2}A \\ I_2 = -1A \end{cases}$$

Then $I = I_1 - I_2 = \frac{5}{2}A$

The power dissipated by the 4Ω resistor is:

$$P = I^2 \cdot 4\Omega = \left(\frac{5}{2}A\right)^2 \cdot 4\Omega = 25\mathrm{W}$$

Finish.

Question 2 (12 Marks): Use the node-voltage method to find the value of v_0 in Figure 2.

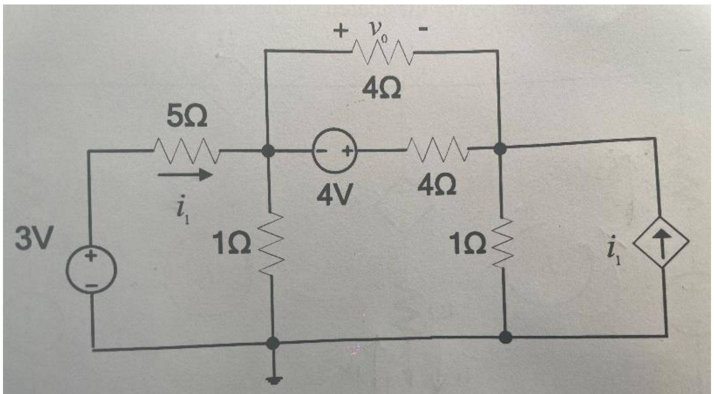


Figure 2

【考点 Point】

节点电流法 Node-voltage method

Answer: -1V.

【解析 Analysis】

直接节点电压法求解就可以了，注意参考点的选择。

Solution:

We set the reference point and the node point as the picture below.

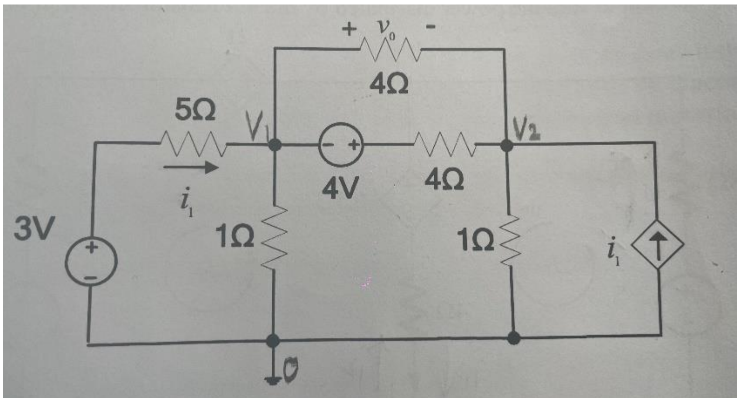


Figure 2

By node-voltage method, we have the equations

$$\begin{cases} -i_1+\dfrac{v_1}{1}+\dfrac{v_0}{4}+\dfrac{v_1+4-v_2}{4}=0 \\ -i_1+\dfrac{v_2}{1}+\dfrac{-v_0}{4}+\dfrac{v_2-v_1-4}{4}=0 \end{cases}$$

Since $i_1 = \frac{3-v_1}{5}$ and $v_0 = v_1 - v_2$,we have

$$\begin{cases} \frac{v_1 - 3}{5} + \frac{v_1}{1} + \frac{v_1 - v_2}{4} + \frac{v_1 + 4 - v_2}{4} = 0 \\ \frac{v_1 - 3}{5} + \frac{v_2}{1} + \frac{v_2 - v_1}{4} + \frac{v_2 - v_1 - 4}{4} = 0 \end{cases}$$

That is,

$$\begin{cases} \frac{17}{10}v_1 - \frac{1}{2}v_2 + \frac{2}{5} = 0 \\ -\frac{3}{10}v_1 + \frac{3}{2}v_2 - \frac{8}{5} = 0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} v_1 = \frac{1}{12}V \\ v_2 = \frac{13}{12}V \end{cases}$$

Then $v_0 = v_1 - v_2 = -1V$ Finish.

Question 3 (13 Marks): Find the Thevenin equivalent circuit with respect to the terminals a and b in the circuit shown in Figure 3.

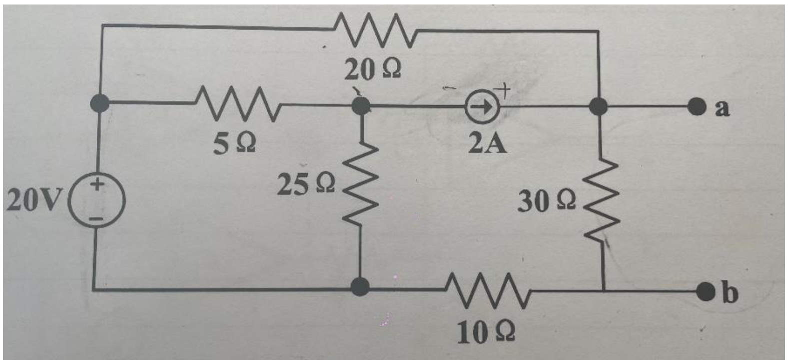
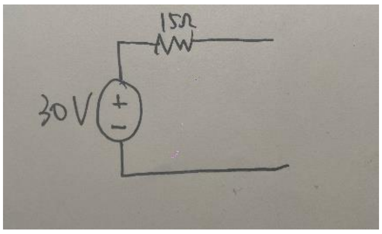


Figure 3

【考点 Point】

求解戴维南等效电路 Find the Thevenin Equivalent circuit

Answer: 

【解析 Analysis】

本题为求解戴维南等效电路，要解的是两个量，戴维南电压和戴维南电阻R_{Th}。

戴维南电压即开路电压，直接用平常解电压的方法求解即可。(节点/网孔)

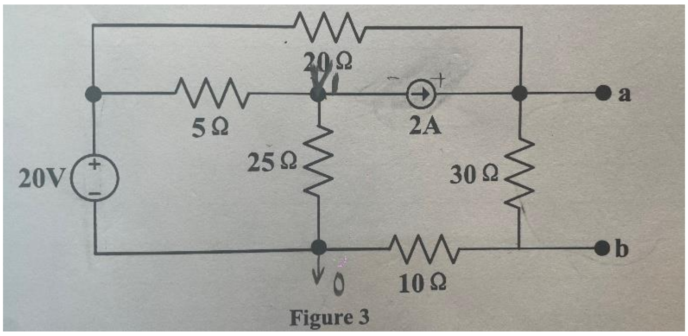
对于戴维南电阻, 本题无受控源只有独立源, 可以使用开路电压短路电流的方法, 也可以使用除源法（电压表短路，电流表断路）。

Solution:

Part 1：求解戴维南电压V_{Th}

Method 1：节点电压法

We set the reference point and the node point as the picture below.



By node-voltage method, we have the equations

$$\begin{cases} \dfrac{v_1}{25} + \dfrac{v_1 - 20}{5} + 2 = 0 \\ \dfrac{v_a - v_b}{30} - 2 + \dfrac{v_a - 20}{20} = 0 \\ \dfrac{v_b}{10} + \dfrac{v_b - v_a}{30} = 0 \end{cases}$$

That is,

$$\begin{cases} \frac{6}{25}v_1 - 2 = 0 \\ \frac{1}{12}v_a - \frac{1}{30}v_b - 3 = 0 \\ -\frac{1}{30}v_a + \frac{2}{15}v_b = 0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} v_1 = \frac{25}{3}V \\ v_a = 40V \\ v_b = 10V \end{cases}$$

Then $\quad v_{TH} = v_a - v_b = 40V - 10V = 30V$

Method 2：网孔电流法

We set the meshes as the picture below.

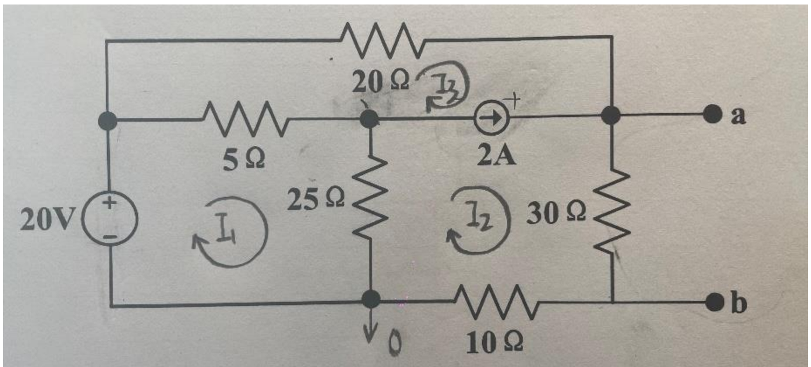


Figure 3

By mesh-current method, we have the equations

$$\begin{cases} 20 - 5(I_1 - I_3) - 25(I_1 - I_2) = 0 \\ -25(I_2 - I_1) - 5(I_3 - I_1) - 20I_3 - 30I_2 - 10I_2 = 0 \end{cases}$$

Since $2A = I_2 - I_3$,that is $I_3 = (I_2 - 2)A$,we have

$$\begin{cases} 20 - 5(I_1 - I_2 + 2) - 25(I_1 - I_2) = 0 \\ -25(I_2 - I_1) - 5(I_2 - 2 - I_1) - 20(I_2 - 2) - 30I_2 - 10I_2 = 0 \end{cases}$$

That is,

$$\begin{cases} -30I_1 + 30I_2 + 10 = 0 \\ 30I_1 - 90I_2 + 50 = 0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} I_1 = \dfrac{4}{3}A \\ I_2 = 1A \end{cases}$$

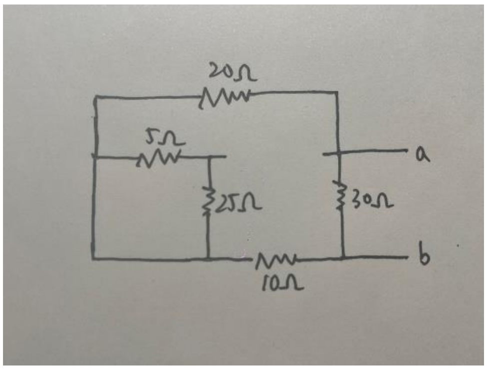
Then $\quad V_{TH} = I_2 \cdot 30\Omega = 1A \cdot 30\Omega = 30V$

Next, we find the Thevenin equivalent resistor.

Part 2：求解戴维南电阻$R_{T\hbar}$

Method 1：除源法

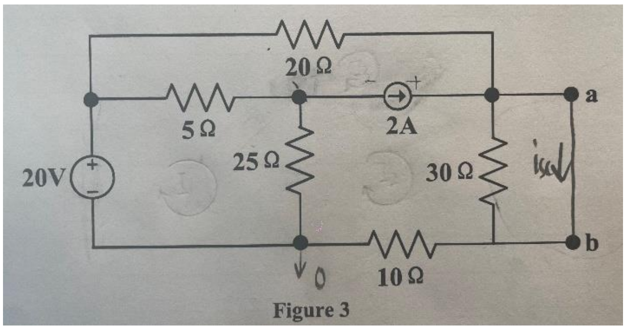
By the method of deactivating sources, we have the circuit:



Then $R_{T\hbar} = (20 + 10)||30 = 15\Omega$

Method 2：短路电流法

By the method of short-circuit current, we have the circuit:



（这里只给了节点电压法，网孔电流就不再赘述了~）

By node-voltage method, we set the reference point and the node point as the picture below:

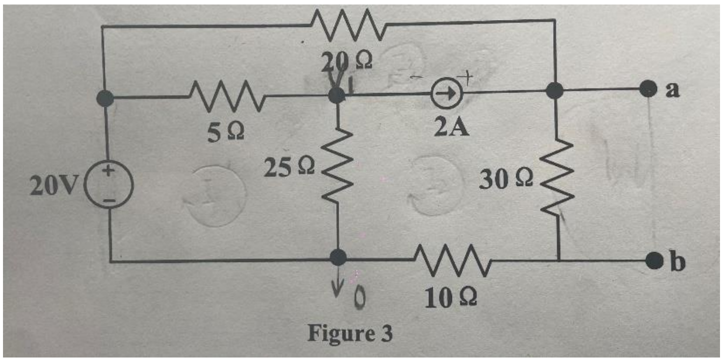


Figure 3

We have the equations:

$$\begin{cases} \dfrac{v_1}{25} + \dfrac{v_1 - 20}{5} + 2 = 0 \\ -2 + \dfrac{v_a - 20}{20} + i_{sc} = 0 \\ \dfrac{v_b}{10} - i_{sc} = 0 \end{cases}$$

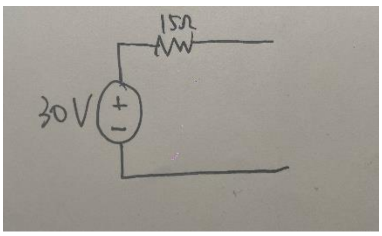
That is,

$$\begin{cases} \dfrac{6}{25} v_1 - 2 = 0 \\ \dfrac{1}{20} v_a + i_{sc} - 3 = 0 \\ \dfrac{1}{10} v_b - i_{sc} = 0 \end{cases}$$

Since $v_b = v_a$ By solving the equations, we have

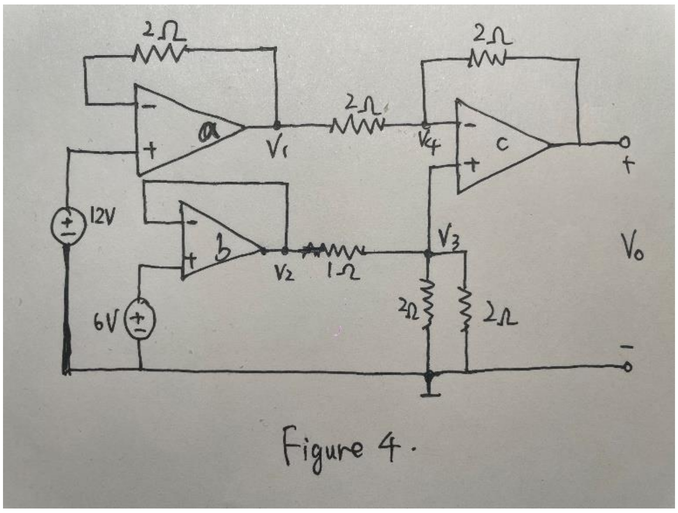
$$\begin{cases} v_1 = \dfrac{25}{3} V \\ v_a = 20V \\ i_{sc} = 2A \end{cases}$$

Then $R_{TH} = \frac{V_{th}}{Isc} = \frac{30V}{2A} = 15\Omega$



Finally, we find the Thevenin equivalent circuit.

Question 4 (12 Marks): The operational amplifiers in the circuit shown in Figure 4 are ideal. Find the voltage $\boldsymbol{V_0}$.



【考点 Point】

运算放大器 Op amp

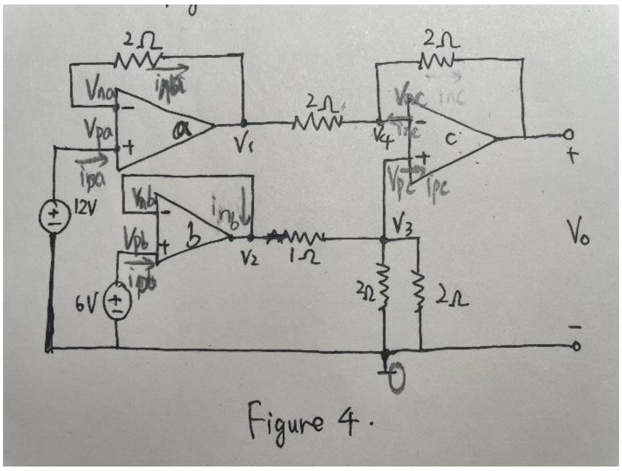
Answer: -6V.

【解析 Analysis】

本题考察运算放大器。核心在于“虚短路，虚开路。”

别看是级联，电路很复杂，其实处处藏关系。靠上述六个字就能够化简绝大多数的部分。不要恐惧哦~

Solution:



$v_{pa} = v_{na} = 12V$, $v_{pb} = v_{nb} = 6V$, $v_{pc} = v_{nc}$

$$i_{pa} = i_{na} = i_{pb} = i_{nb} = i_{pc} = i_{nc} = 0$$

（记住！碰到运算放大器看着电路就不想做的，别怕，先把上面所有的虚短路虚开路写上，有分的!!!!）

Also, $v_1 = v_{na} = 12V$, $v_2 = v_{nb} = 6V$, $v_3 = v_4$

下面用节点电压法解需要的电压$\boldsymbol{V_0}$.

By node-voltage method, we have the equations

$$\begin{cases} \dfrac{v_3 - v_2}{1} + \dfrac{v_3}{2} + \dfrac{v_3}{2} = 0 \\ \dfrac{v_4 - v_0}{2} + \dfrac{v_4 - v_1}{2} = 0 \end{cases}$$

That is,

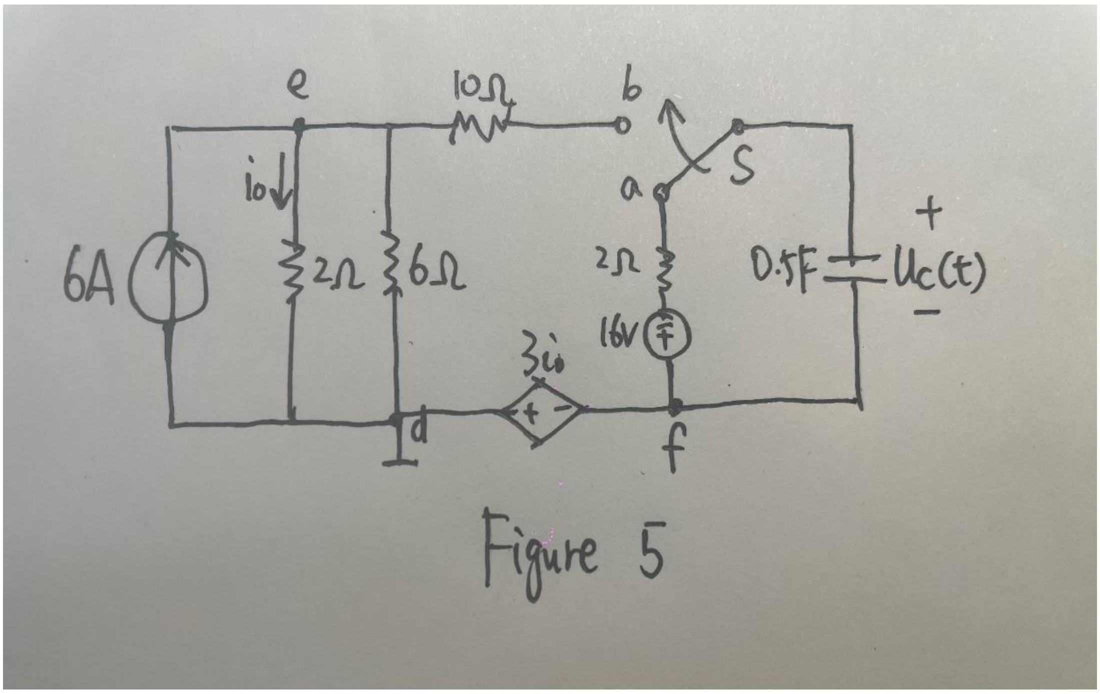
$$\begin{cases} 2v_3 - v_2 = 0 \\ v_4 - \frac{1}{2}v_0 - \frac{1}{2}v_1 = 0 \end{cases} \quad -> \quad \begin{cases} 2v_3 - 6 = 0 \\ v_3 - \frac{1}{2}v_0 - 6 = 0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} v_3 = 3V \\ v_0 = -6V \end{cases}$$

Finish.

Question 5 (12 Marks): The switch in the circuit in Figure 5 has been in position $\boldsymbol{a}$ for a long time. At $\boldsymbol{t = 0}$ the seitch is moved to position $\boldsymbol{b}$. Find $\boldsymbol{u_c(t)}$ for $\boldsymbol{t \geq 0}$.



【考点 Point】

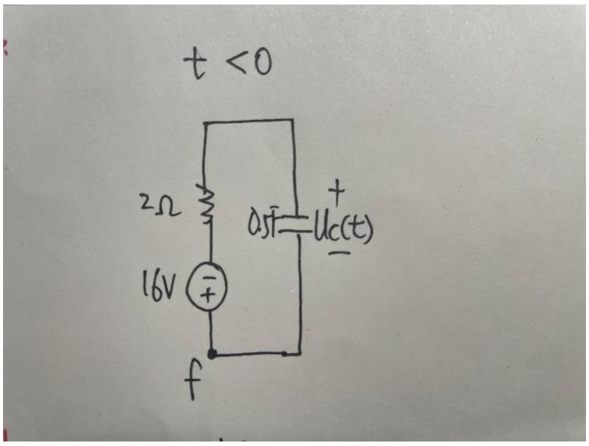
自然响应 Natural Responses in an RC circuit.

Answer: $\boldsymbol{u_c(t) = -16e^{-\frac{8}{55}t}(t \geq 0)}$.

【解析 Analysis】

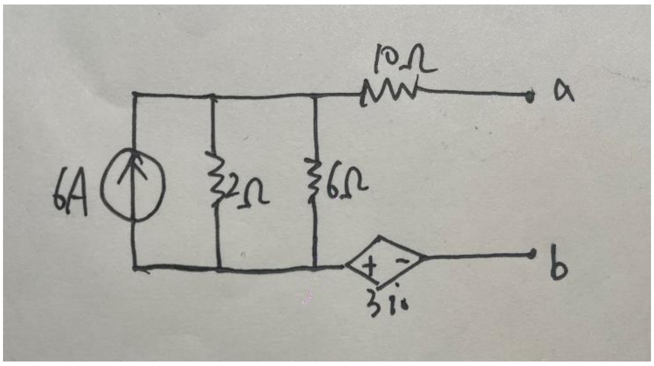
本题考察电容自然响应的电路分析。分别对$t<0$和$t\geq 0$的电路进行求解，还是老三步：初态、时间常数以及写表达式。初态可以直接根据 t<0 的电路写出，时间常数是求解戴维南电阻+电容，表达式就是带个自然常数。在这个思路下，可以求得我们需要的电容的电压随时间变化的函数。

Solution:



$$u_c(0) = -16V$$

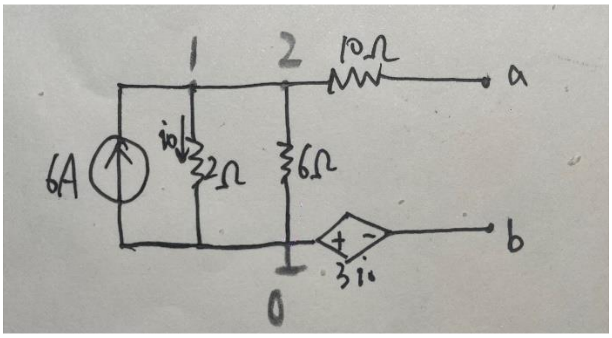
Then we find the Thevenin equivalent circuit at t>0.



Part 1：求解戴维南电压V_{Th}

这里只提供节点电压法，网孔电流不赘述了~

We set the reference point and the node point as the picture below.



By node-voltage method, we have the equations $i_0 + \frac{i_0}{3} - 6 = 0$

By solving the equations, we have

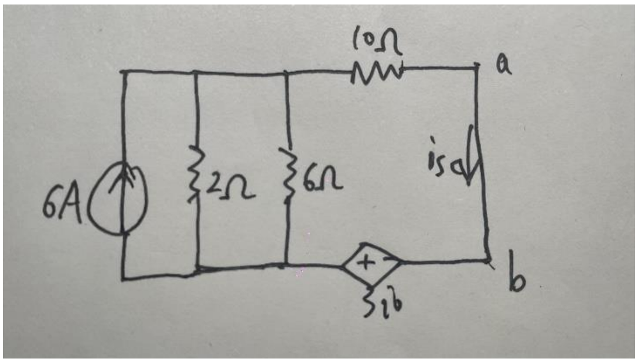
$$i_0 = \frac{9}{2}A$$

Then $v_{TH} = v_a - v_b = 2i_0 - (-3i_0) = 5i_0 = 22.5V$

Part 2：求解戴维南电阻R_{Th}

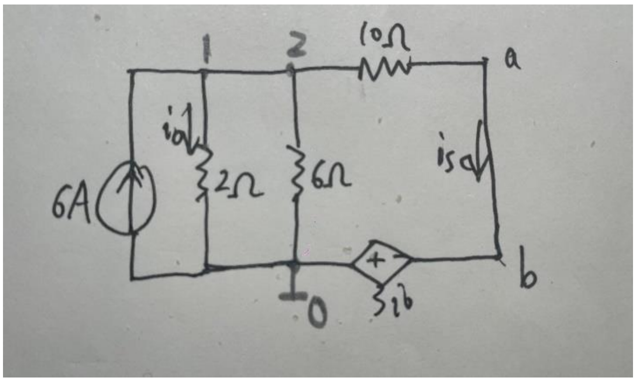
使用短路电流法求解。

By the method of short-circuit current, we have the circuit:



（这里只给了节点电压法，网孔电流就不再赘述了~）

By node-voltage method, we set the reference point and the node point as the picture below:



We have the equations:

$$\begin{cases} i_0 + \dfrac{i_0}{3} - 6 + i_{sc} = 0 \\ i_{sc} = \dfrac{v_2 - v_a}{10} \end{cases}$$

Since $v_b = v_a = -3i_0$, $v_1 = v_2 = 2i_0$

By solving the equations, we have

$$\begin{cases} i_0 + \frac{i_0}{3} - 6 + i_{sc} = 0 \\ i_{sc} = \frac{1}{2}\, i_0 \end{cases}$$

That is:

$$\begin{cases} \frac{11}{6} i_0 - 6 = 0 \\ i_{sc} = \frac{1}{2}\, i_0 \end{cases}$$

By solving the equations, we have:

$$\begin{cases} i_0 = \frac{36}{11} A \\ i_{sc} = \frac{18}{11} A \end{cases}$$

Then $\quad R_{TH} = \frac{V_{th}}{Isc} = \frac{22.5V}{\frac{18}{11}A} = 13.75\Omega$

Then, the time constant of the capacitance is:

$$\tau = R_{TH}C = 6.875s$$

Then, the expression of $\boldsymbol{u_c(t)}$ is:

$$\boldsymbol{u_c(t) = -16e^{-\frac{8}{55}t}(t \geq 0)}$$

Finish.

Question 6 (13 Marks): Use node voltage method to find the current $\boldsymbol{I}$ in the circuit in Figure 6.

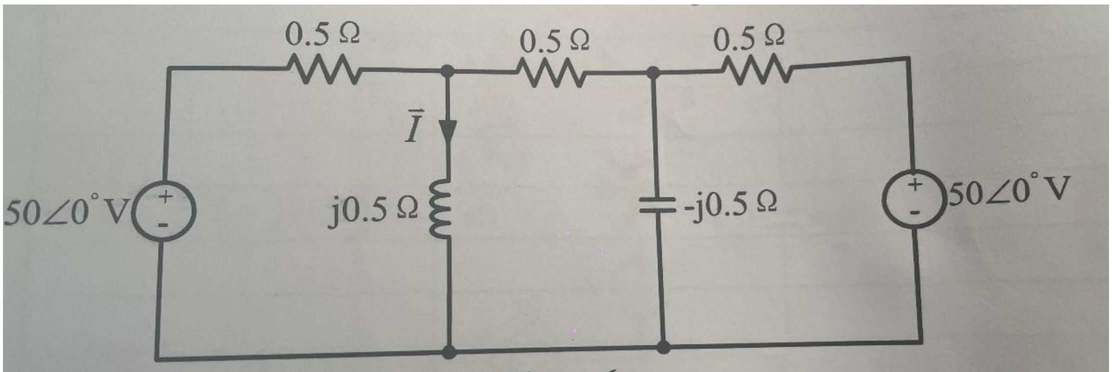


Figure 6

【考点 Point】

正弦稳态分析 The analysis of steady sinusoidal circuit

Answer: $(25-75j)A$ / $25\sqrt{10}\angle-71.57°A$ /

$25\sqrt{10}\cos{(\omega t-71.57°)}(A)$.

【解析 Analysis】

正弦稳态电路分析。和正常电路没啥区别，就多个复数计算。然后按题目要求节点电压法解就 ok 了。

Solution:

We set the reference point and the node point as the picture below.

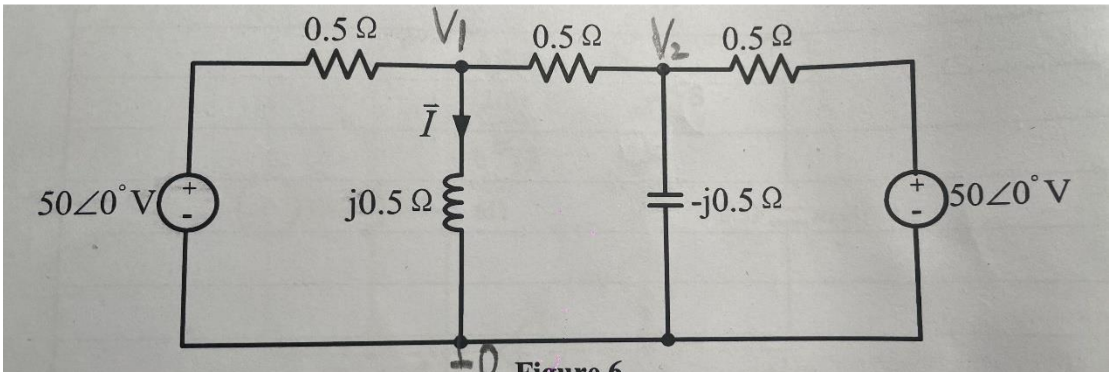


Figure 6

By node-voltage method, we have the equations

$$\begin{cases} \dfrac{v_1 - 50\angle 0°}{0.5} + \dfrac{v_1}{j0.5} + \dfrac{v_1 - v_2}{0.5} = 0 \\ \dfrac{v_2 - 50\angle 0°}{0.5} + \dfrac{v_2}{-j0.5} + \dfrac{v_2 - v_1}{0.5} = 0 \end{cases}$$

That is,

$$\begin{cases} (4-2j)v_1 - 2v_2 - 100\angle 0° = 0 \\ -2v_1 + (4+2j)v_2 - 100\angle 0° = 0 \end{cases}$$

$$(4-2j)v_1 - 2v_2 = -2v_1 + (4+2j)v_2$$

$$(6-2j)v_1 = (6+2j)v_2$$

Then, $v_2 = \frac{6-2j}{6+2j} v_1 = \left(\frac{4}{5} - \frac{3}{5}j\right) v_1$

By solving the equations, we have

$$\left(\frac{12}{5} - \frac{4}{5}j\right) v_1 = 100$$

$$v_1 = (\frac{75}{2} + \frac{25}{2}\mathrm{j})V$$

Then $I = \frac{v_1}{j0.5} = (25 - 75j)A$

$$= 25\sqrt{10}\angle - 71.57°A$$

$$= 25\sqrt{10}\cos(\omega t - 71.57°)(A)$$

Finish.

Question 7 (13 Marks)——For Classes 1-16 Only:

Determine the current I_0 in Figure 7 with superposition method.

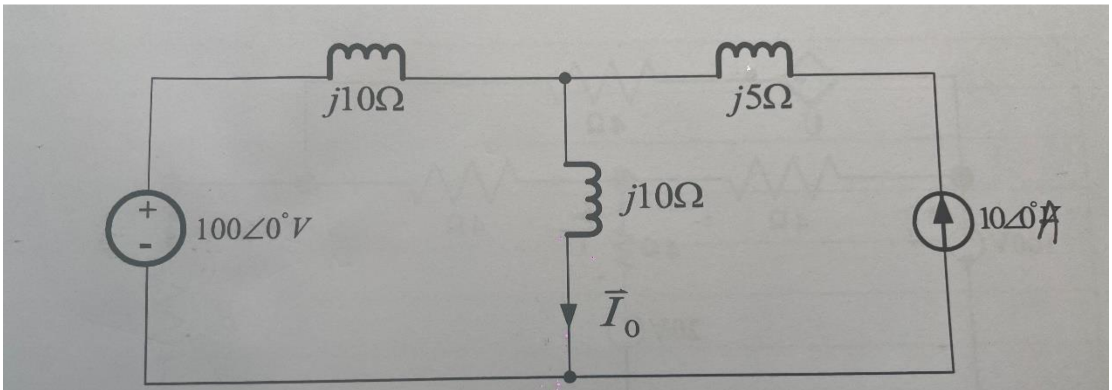


Figure 7

【考点 Point】

叠加法 Superposition Method

Answer: $5-5jA$ / $5\sqrt{2}\angle-45°A$ / $5\sqrt{2}cos(\omega t-45°)(A)$.

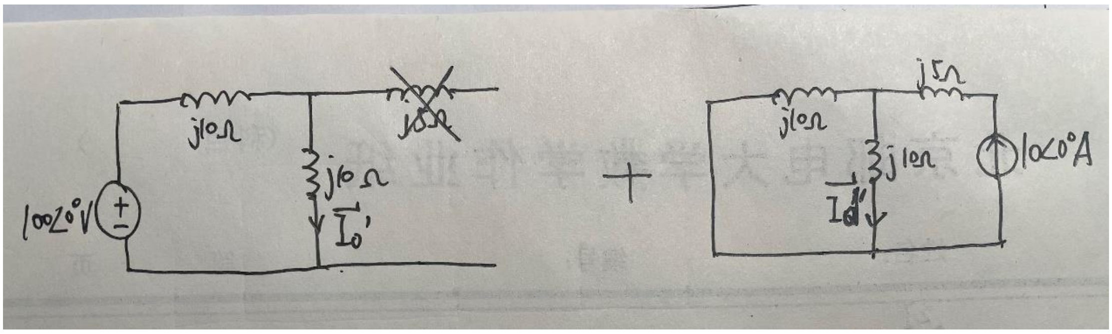
【解析 Analysis】

叠加法来个简单复习：每次拆掉一个独立源（电压表短路、电流表断路）。

然后分别对每个电路的$\boldsymbol{I_0}$进行求解，再把所有的分$\boldsymbol{I_0}$加起来，得到答案。

Solution:

By superposition method, since there are two independent sources, so we have two circuits to find the $\boldsymbol{I_0}$.



$$I_0{}' = \frac{100\angle 0°}{j20}A = j-5A$$

$$2I_0'' - 10\angle 0° = 0$$

$$I_0'' = 5\angle 0°A$$

Then,

$$I_0 = I_0' + I_0'' = 5 - 5jA$$

$$I_0 = 5\sqrt{2}\angle -45°A$$

$$I_0 = 5\sqrt{2}cos(\omega t - 45°)(A)$$

Finish.

Question 8 (13 Marks)——For Classes 1-16 Only:

In the circuit in Figure 8, what resistor R_L will absorb the maximum power? And what is the maximum power?

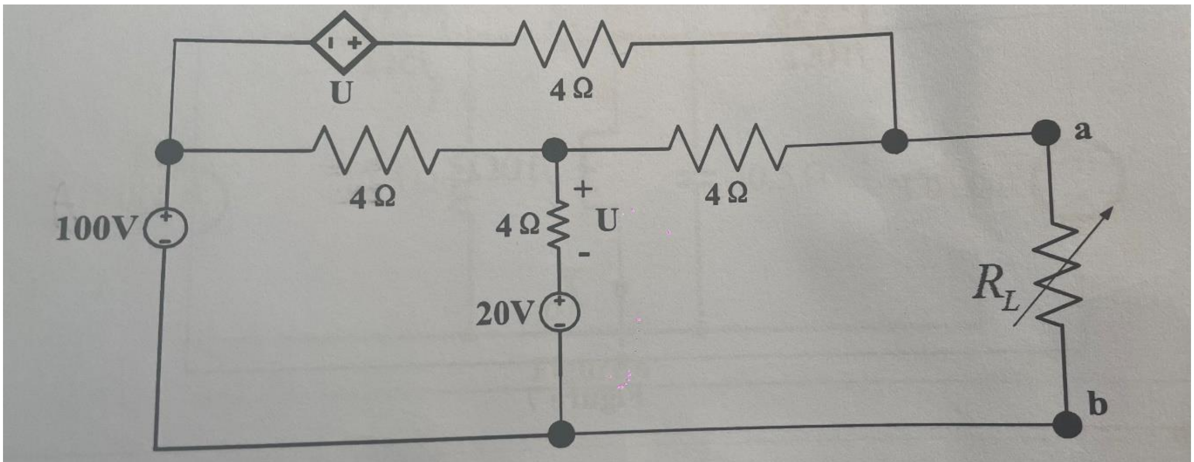


Figure 8

【考点 Point】

最大功率传输 Maximum Power transformation

戴维南等效电路求解 Find the Thevenin Equivalent Circuit

Answer: $3\Omega,\quad 1200W.$

【解析 Analysis】

电路达到最大功率是当外阻等于内阻的时候。我们需要先求出戴维南等效电路，

之后当 RL=戴维南电阻可以得到功率最大值（理论解释部分请看教材或各任课教

师 ppt)。在本道题的戴维南电路求解，仍然给出节点/网孔双解法（求解戴维南电压），因本题存在受控源，不能使用除源法，且因为独立源存在，我们只能用开路电压短路电流的方法来求解戴维南电阻。

所以说白，解对戴维南等效电路，是解对本题的关键！

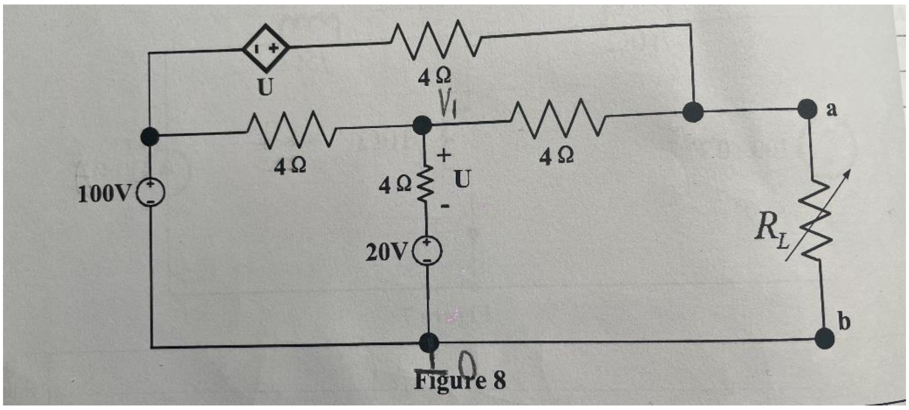
Solution:

First, we find the Thevenin Equivalent circuit.

Part 1：求解戴维南电压V_{Th}

Method 1：节点电压法

We set the reference point and the node point as the picture below.



By node-voltage method, we have the equations

$$\begin{cases} \dfrac{v_1-20}{4}+\dfrac{v_1-100}{4}+\dfrac{v_1-v_a}{4}=0 \\ \dfrac{v_a-v_1}{4}+\dfrac{v_a-100-U}{4}=0 \end{cases}$$

Since $U=(v_1-20)V$, we have

$$\begin{cases} \dfrac{v_1-20}{4}+\dfrac{v_1-100}{4}+\dfrac{v_1-v_a}{4}=0 \\ \dfrac{v_a-v_1}{4}+\dfrac{v_a-100-(v_1-20)}{4}=0 \end{cases}$$

That is,

$$\begin{cases} 3v_1-120-v_a=0 \\ 2v_a-2v_1-80=0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} v_1 = 80V \\ v_a = 120V \end{cases}$$

Since $v_b = 0V$, then

$$v_{TH} = v_a - v_b = 120V - 0V = 120V$$

Method 2：网孔电流法

We set the meshes as the picture below.

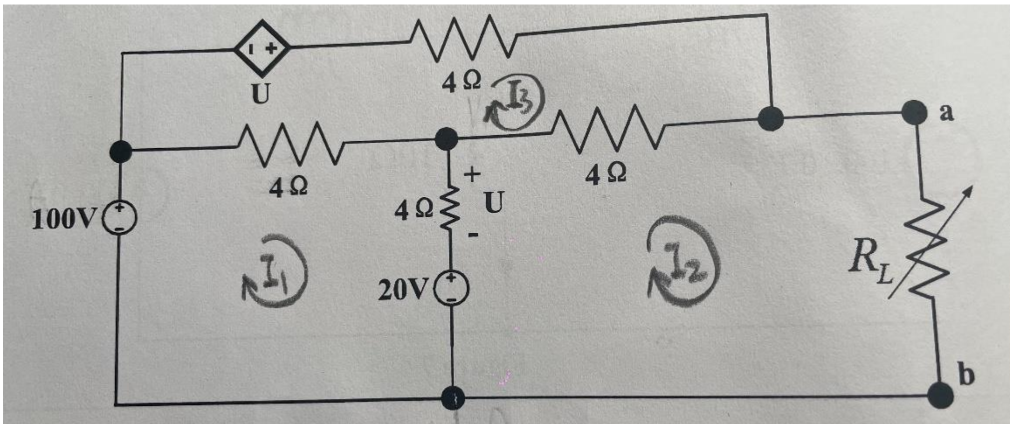


Figure 8

By mesh-current method, we have the equations

$$\begin{cases} 100 - 4(I_1 - I_3) - U - 20 = 0 \\ 20 + U - 4(I_2 - I_3) - v_{ab} = 0 \\ U - 4I_3 - 4(I_3 - I_2) - 4(I_3 - I_1) = 0 \end{cases}$$

Since $U = 4(I_1 - I_2)V$, we have

$$\begin{cases} 100 - 4(I_1 - I_3) - 4(I_1 - I_2) - 20 = 0 \\ 20 + 4(I_1 - I_2) - 4(I_2 - I_3) - v_{ab} = 0 \\ 4(I_1 - I_2) - 4I_3 - 4(I_3 - I_2) - 4(I_3 - I_1) = 0 \end{cases}$$

That is,

$$\begin{cases} -8I_1 + 4I_2 + 4I_3 + 80 = 0 \\ 4I_1 - 8I_2 + 4I_3 + 20 - v_{ab} = 0 \\ 8I_1 - 12I_3 = 0 \end{cases}$$

Then, $I_1 = 1.5I_3$.

Since the voltage at the terminal a and b is open-circuit, then $I_2 = 0$

Then,

$$\begin{cases} -8I_3 + 80 = 0 \\ 10I_3 + 20 - v_{ab} = 0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} I_1 = 15A \\ I_2 = 0A \\ I_3 = 10A \\ v_{ab} = 120V \end{cases}$$

Next, we find the Thevenin equivalent resistor.

Part 2：求解戴维南电阻R_{Th}

使用短路电流法求解。

By the method of short-circuit current, we have the circuit:

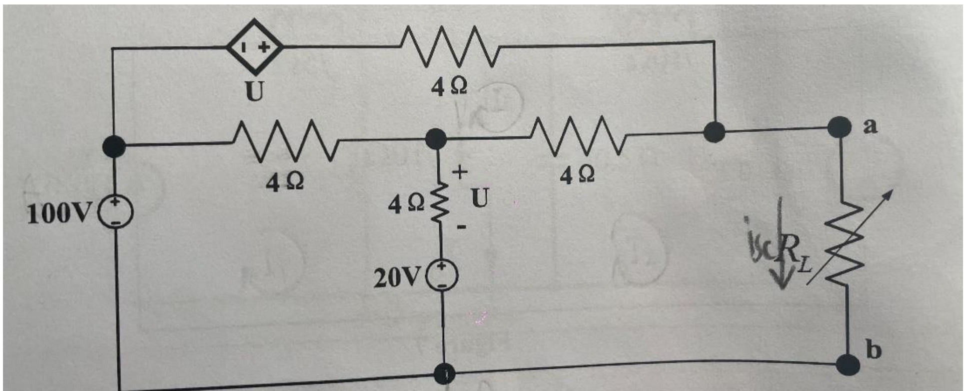
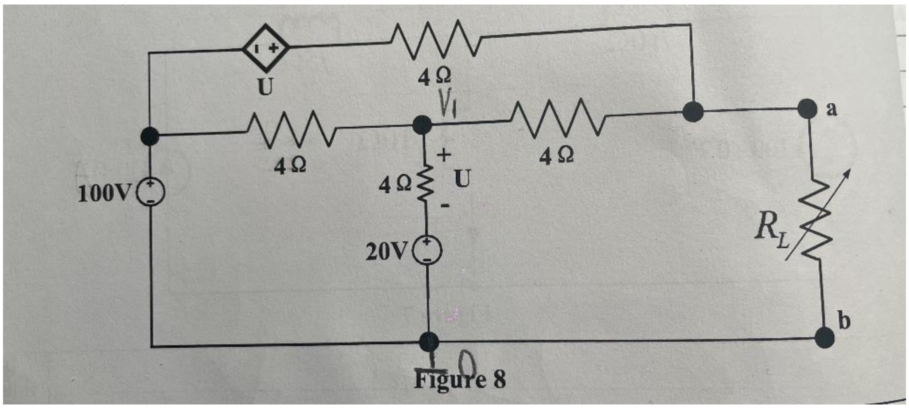


Figure 8

（这里只给了节点电压法，网孔电流就不再赘述了~）

By node-voltage method, we set the reference point and the node point as the picture below:



And we have the equations:

$$\begin{cases} \dfrac{v_1 - 20}{4} + \dfrac{v_1 - 100}{4} + \dfrac{v_1 - v_a}{4} = 0 \\ \dfrac{v_a - v_1}{4} + \dfrac{v_a - 100 - U}{4} + i_{sc} = 0 \end{cases}$$

Since $U = (v_1 - 20)V$, we have

$$\begin{cases} \dfrac{v_1 - 20}{4} + \dfrac{v_1 - 100}{4} + \dfrac{v_1 - v_a}{4} = 0 \\ \dfrac{v_a - v_1}{4} + \dfrac{v_a - 100 - (v_1 - 20)}{4} + i_{sc} = 0 \end{cases}$$

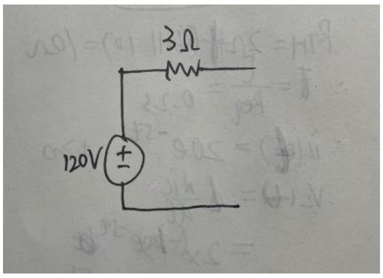
That is,

$$\begin{cases} 3v_1 - 120 - v_a = 0 \\ 2v_a - 2v_1 - 80 + 4i_{sc} = 0 \end{cases}$$

Since $v_b = v_a = 0$ By solving the equations, we have

$$\begin{cases} v_1 = 40V \\ i_{sc} = 40A \end{cases}$$

Then $R_{TH} = \frac{V_{th}}{Isc} = \frac{120V}{40A} = 3\Omega$



We find the Thevenin equivalent circuit.

When $R_L = R_{TH} = 3\Omega$, the resistor will absorb the maximum power, and the power is $P_{max} = \frac{(V_{Th})^2}{4R_L} = 1200W$ Finish.

EEF 部分

Question 9 (10 Marks)——For Classes 17-22 Only:

In the circuit shown in Figure 9, $V_s = 12V$, $R_L = 500\Omega$. For the Zener diode D, the regulation voltage $V_Z = 10V$, the maximum regulation current $I_{Zmax} = 50mA$, and the minimum regulation current $I_{Zmin} = 30mA$. Determine the maximum and minimum values of the resistor R.

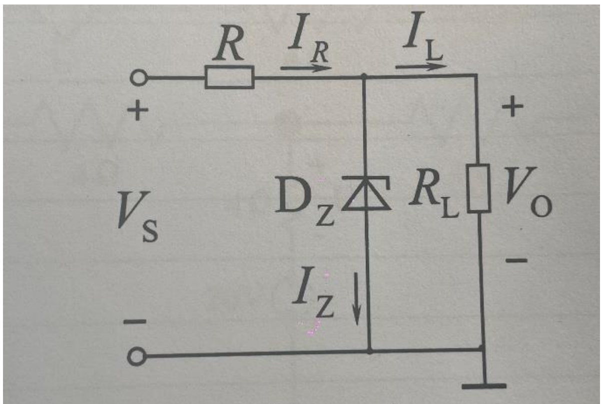


Figure 9

【考点 Point】

二极管求限制电阻的范围 Find the range of a restrict resistor in a circuit with Semiconductor.

Answer: Max: 40Ω, Min: 28.57Ω.

【解析 Analysis】

模电二极管稳压电路考点。先求负载电阻上的电流，然后求限流电阻上的电压，根据限流电阻上最大和最小电流的取值，分别求得电阻的最小值和最大值。

Solution:

$$V_0 = V_Z = 10V$$

The current on the load resistor R_L is: $I_L = \frac{V_0}{R_L} = \frac{10V}{500\Omega} = 20mA$

The voltage of the resistor R is $V_R = V_S - V_0 = 2V$.

The maximum of the current passing the resistor R is:

$$I_{Rmax} = I_L + I_{Zmax} = 20mA + 50mA = 70mA$$

The minimum of the current passing the resistor R is:

$$I_{Rmin} = I_L + I_{Zmin} = 20mA + 30mA = 50mA$$

The maximum of the resistor R is:

$$R_{max} = \frac{V_R}{I_{Rmin}} = \frac{2V}{50mA} = 40\Omega$$

The minimum of the resistor R is:

$$R_{min} = \frac{V_R}{I_{Rmax}} = \frac{2V}{70mA} = 28.57\Omega$$

Finish.

Question 10 (16 Marks)——For Classes 17-22 Only:

The common-emitter BJT circuit is shown in Figure 10.

(1)Asusume $\boldsymbol{\beta = 100}$ and $\boldsymbol{V_{BEQ} = 0.6V}$, analyze the Q-point, including $\boldsymbol{I_{BQ}}$, $\boldsymbol{V_{CEQ}}$, $\boldsymbol{I_{CQ}}$;

(2)Assume $\boldsymbol{r_{bb'} = 0}$ and $\boldsymbol{r_{ce} = \infty}$, draw its small-signal hybrid-$\boldsymbol{\pi}$ equivalent circuit and calculate the BJT equivalent resistance $\boldsymbol{r_{b'e}}$ and voltage gain $\boldsymbol{A_v}$.

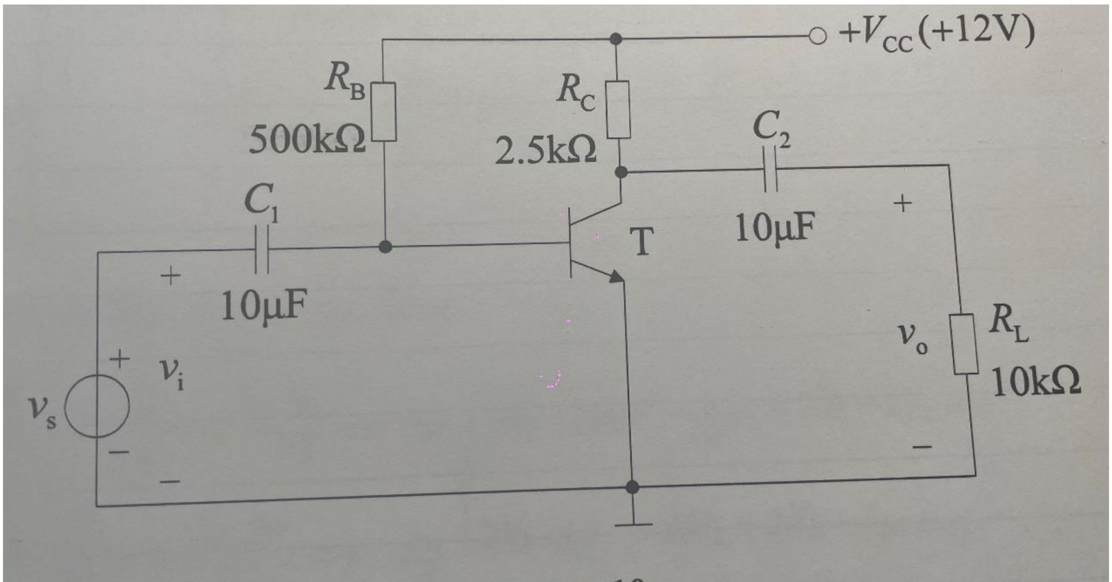


Figure 10

【考点 Point】

三极管（双极型晶体管）电路 BJT circuit

静态工作点分析 Analysis of quiet point Q

混合派模型电路 hybrid-Π model circuit

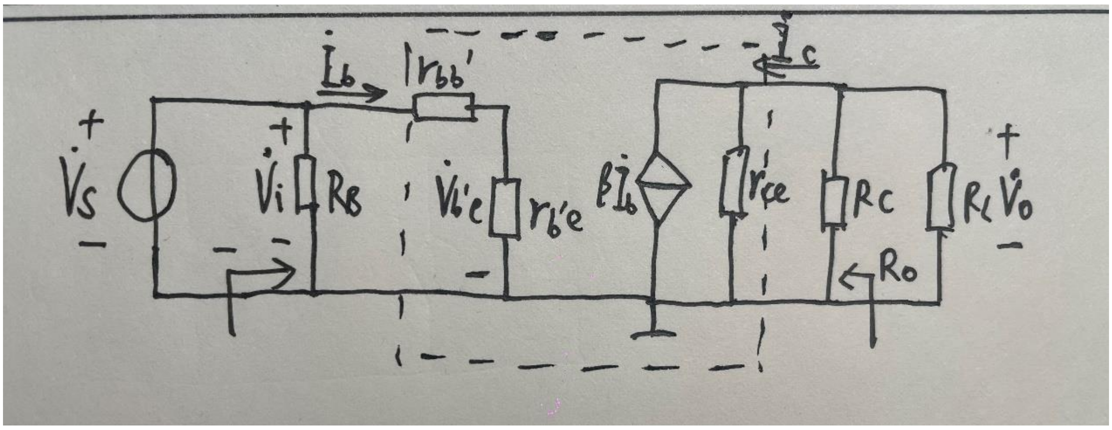
交流动态分析 Dynamic analysis

Answer:

(1) $I_{BQ} = 22.8\mu A, I_{CQ} = 2.28mA, V_{CEQ} = 6.3V$

(2) $r_{b'e} \approx 1.14(k\Omega), A_V \approx -175.4$

Small-signal hybrid-π equivalent circuit:



【解析 Analysis】

模电三极管混合派模型考点。第一问考察静态工作点得情况，根据已知条件和相关公式即可求解这三个量。第二问为交流电路小信号的动态分析。并画出混合派模型的电路图。根据公式可求相关交流分析量。混合派模型电路图只需根据记忆画出即可。

Solution:

(1)

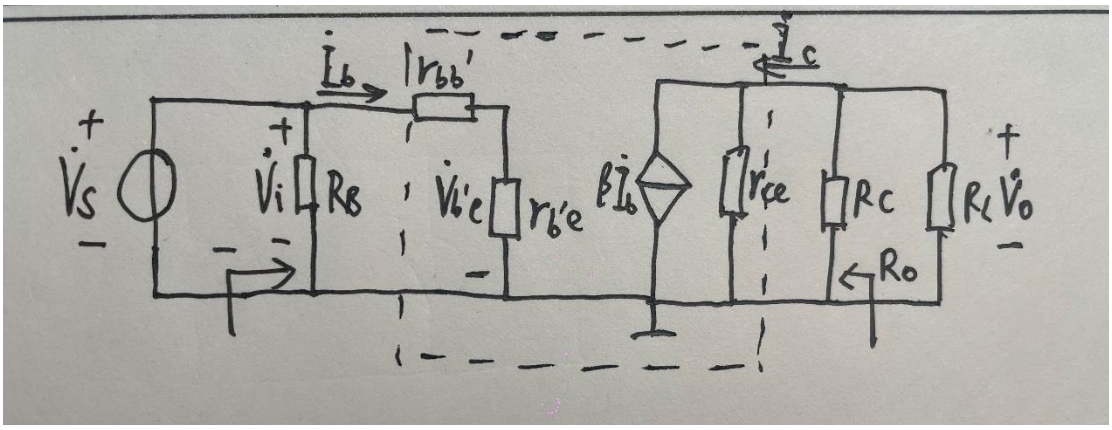
$$I_{BQ}=\frac{V_{CC}-V_{BEQ}}{R_B}=\frac{12V-0.6V}{500k\Omega}=22.8\mu A$$

$$I_{CQ}=\beta I_{BQ}=2.28mA$$

$$V_{CEQ}=V_{CC}-I_{CQ}R_C=12V-2.28mA\times 2.5k\Omega=6.3V$$

(2)

The small-signal hybrid-π equivalent circuit is:



Then, the BJT equivalent resistance $r_{b'e}$ is:

$$r_{b'e}=\frac{V_T}{I_{BQ}}=\frac{26mV}{22.8\times 10^{-3}mA}\approx 1.14(k\Omega)$$

Next, we find the voltage gain.

$$r_{be} = r_{b'e} + r_{bb'} = r_{bb'} + \frac{V_T}{I_{BQ}} = 0 + \frac{V_T}{I_{BQ}} \approx 1.14(k\Omega)$$

Total resistor load is:

$$R_L' = r_{ce} \| R_c \| R_L = 2(k\Omega)$$

The voltage gain A_v is:

$$A_V = \frac{V_0}{V_i} = -\frac{\beta R_L{}'}{r_{be}} \approx -175.4$$

Finish.

考点分析

具体考点:

1、 网孔电流法

2、 节点电压法

3、 戴维南等效电路

4、 运算放大器

5、 自然响应

6、 正弦稳态电路

7、 叠加法+正弦稳态

8、 最大功率传输

9、 二极管 稳压电路 求限流电阻范围

10、 三极管 静态工作点分析+动态交流小信号相关物理量计算