Queen Mary University of London

北京邮电大学

BBC4102 A

Joint Programme Examinations 2016/17

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	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

Complete the information below about yourself very carefully.

QM student number

BUPT student number

Class number

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, Dac Yang

Filename: 1617_BBC4102_A No answerbook required

BBC4102 2016/2017

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 in the circuit in Figure 1.

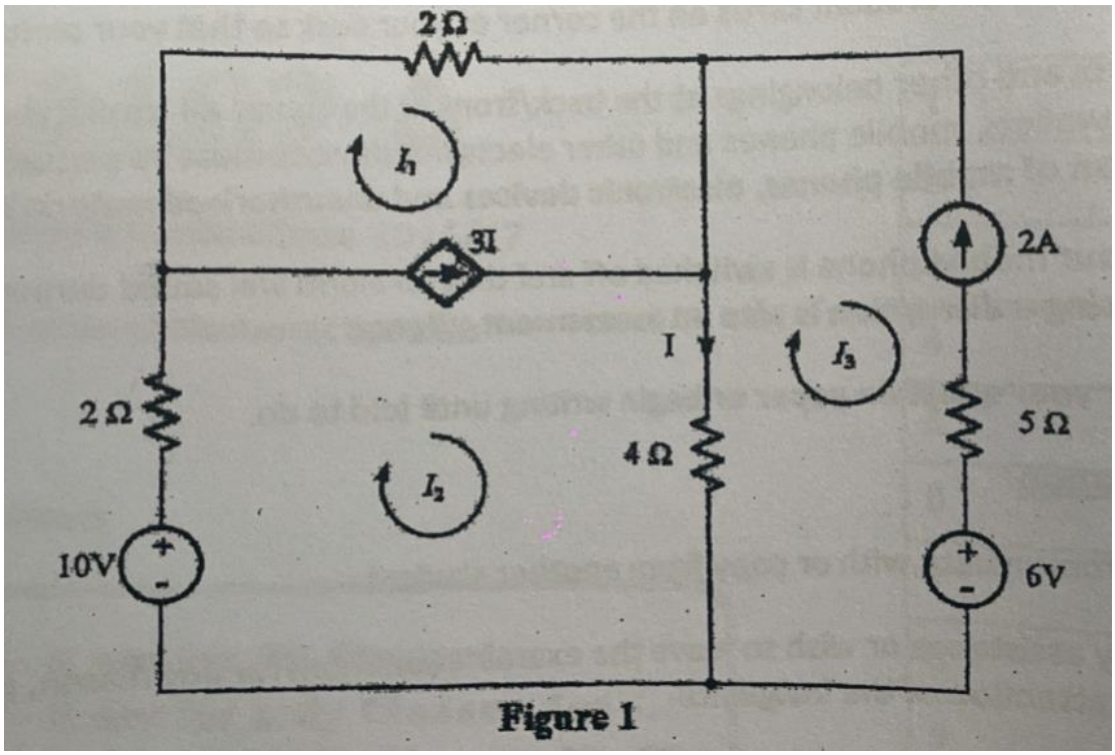


Figure 1

【考点 Point】

网孔电流法 Mesh-current method

电阻功率计算 Find the power of a resistor

Answer: 324W.

【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

$$\begin{cases} 10 - 2I_2 - 2I_1 - 4I = 0 \\ 4I + V_{2A} - 5I_3 - 6 = 0 \end{cases}$$

Since $I = I_2 - I_3$ and $I_3 = -2A$,we have

$$\begin{cases} 10 - 2I_2 - 2I_1 - 4(I_2 + 2) = 0 \\ 4I_2 + V_{2A} + 12 = 0 \end{cases}$$

Since $3I = I_2 - I_1$, then we have $2I_2 + I_1 = -6A$

That is,

$$10 - 2I_2 - 2(-6A - 2I_2) - 4(I_2 + 2) = 0$$

$$14 - 2I_2 = 0$$

By solving the equations, we have

$$\begin{cases} I_1 = -20A \\ I_2 = 7A \end{cases}$$

Then $I = I_2 - I_3 = 9A$

The power dissipated by the 4Ω resistor is:

$$P = I^2 \cdot 4\Omega = (9A)^2 \cdot 4\Omega = 324\text{W}$$

Finish.

Question 2 (12 Marks): Use the Node-Voltage method to find the value of v_0 and i_0 in Figure 2.

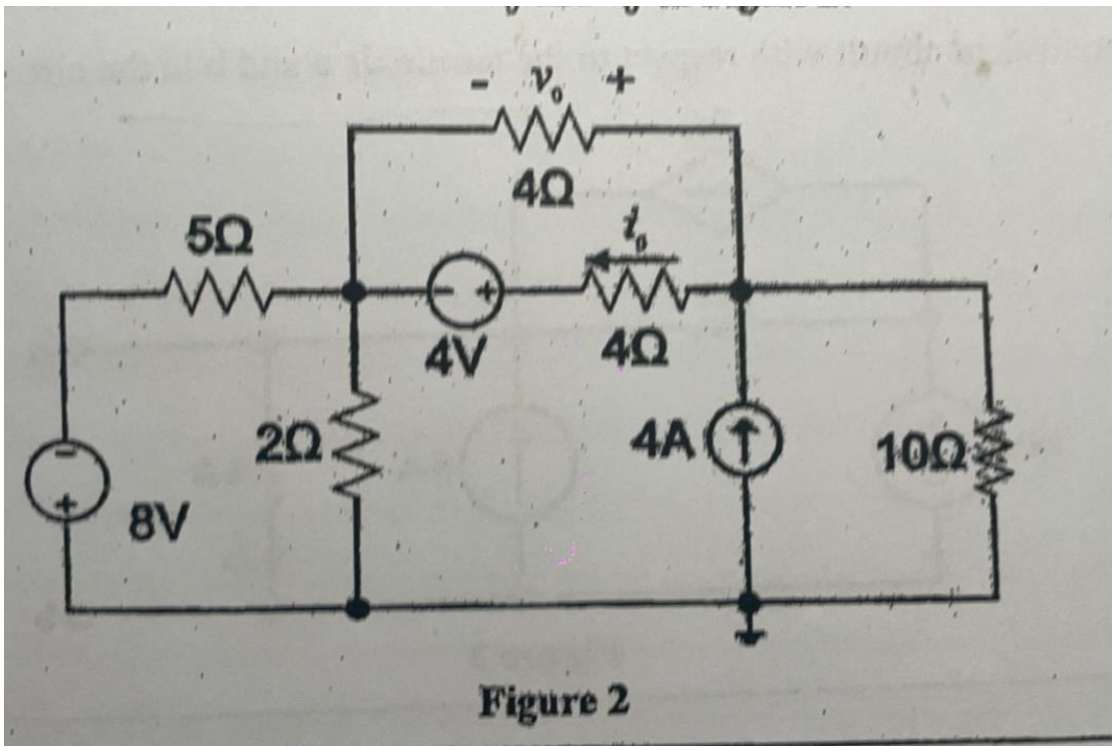


Figure 2

【考点 Point】

节点电流法 Node-voltage method

Answer: 8V, 1A.

【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.

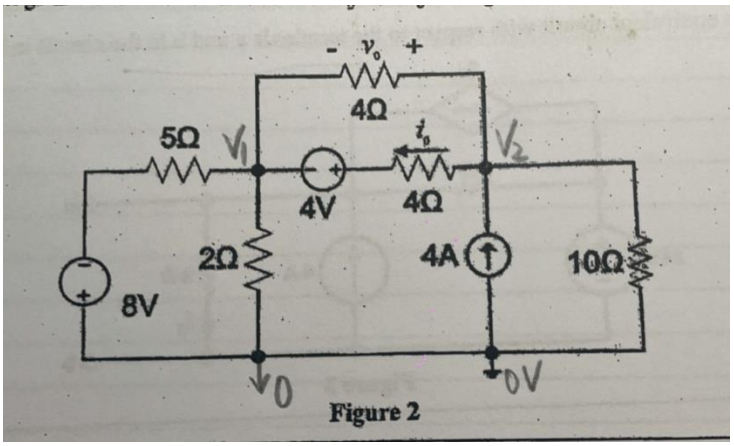


Figure 2

By node-voltage method, we have the equations

$$\begin{cases} \dfrac{v_1-(-8)}{5}+\dfrac{v_1}{2}+\dfrac{v_1-v_2}{4}+\dfrac{v_1+4-v_2}{4}=0 \\ -4+\dfrac{v_2}{10}+\dfrac{v_2-v_1}{4}+\dfrac{v_2-v_1-4}{4}=0 \end{cases}$$

That is,

$$\begin{cases} \dfrac{6}{5}v_1-\dfrac{1}{2}v_2+\dfrac{13}{5}=0 \\ -\dfrac{1}{2}v_1+\dfrac{3}{5}v_2-5=0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} v_1=2V \\ v_2=10V \end{cases}$$

Then $v_0=v_2-v_1=8V$, $i_0=\frac{v_2-v_1-4}{4}=1A$ Finish.

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

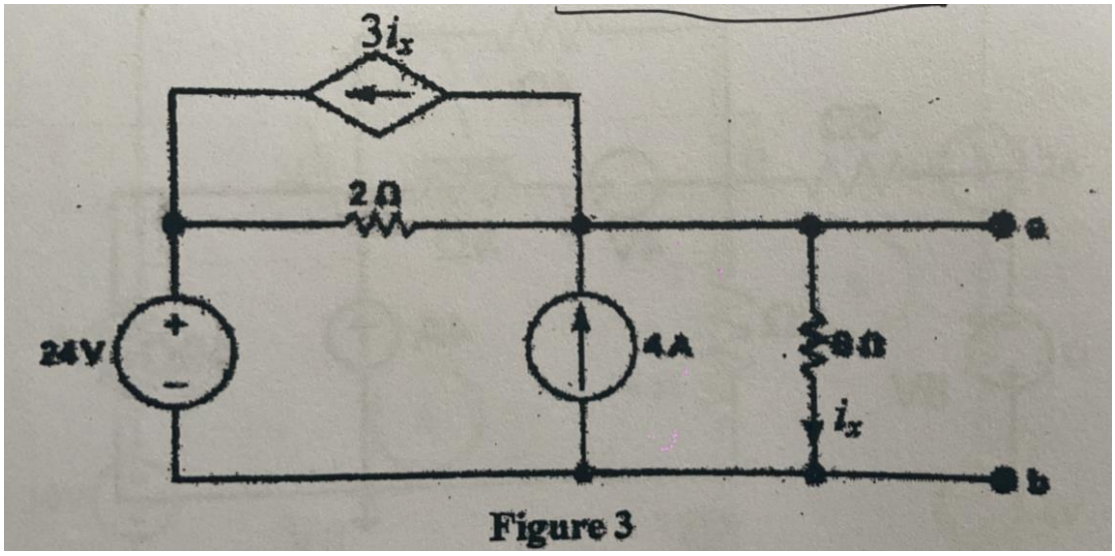
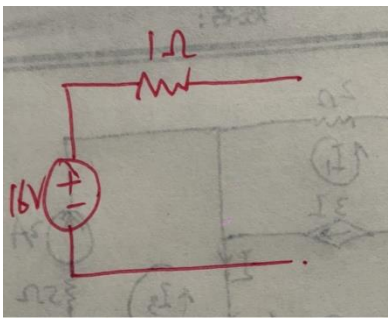


Figure 3

【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）

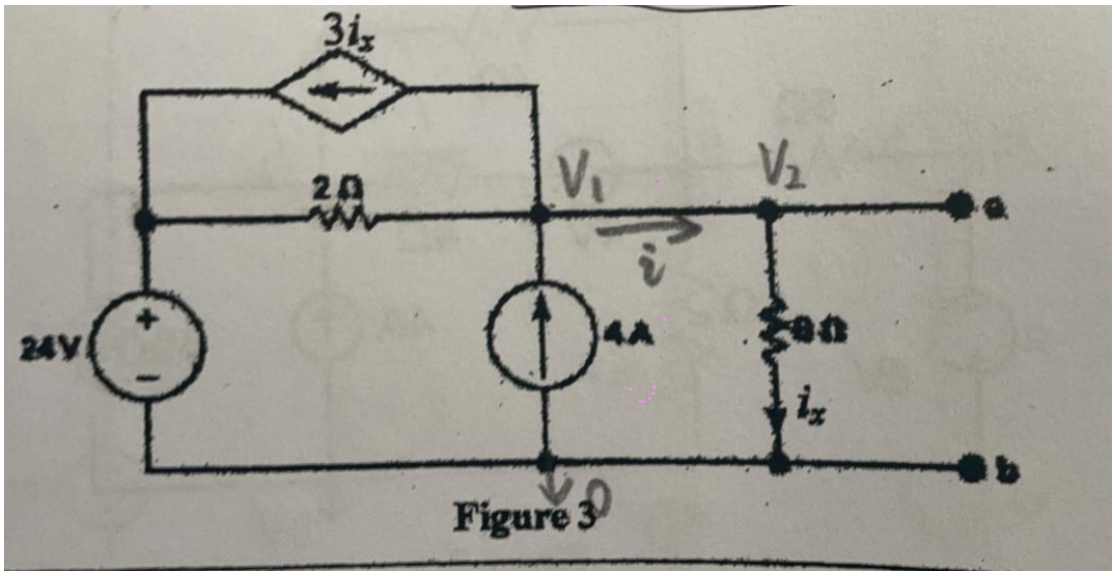
对于戴维南电阻，本题既有受控源又有独立源，故使用开路电压短路电流的方法。

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

$$\begin{cases} \dfrac{v_1 - 24}{2} + i - 4 + 3i_x = 0 \\ \dfrac{v_a}{8} - i = 0 \end{cases}$$

Then, we have $i = \frac{v_a}{8}$.

Since $i = i_x, v_1 = v_a, v_b = 0$, then ,

That is,

$$\frac{v_1 - 24}{2} - 4 + 4i_x = 0$$

$$v_1 - 16 = 0$$

By solving the equations, we have

$$\begin{cases} v_1 = 16V \\ v_a = v_1 = 16V \\ v_b = 0V \end{cases}$$

Then $v_{TH} = v_a - v_b = 16V - 0V = 16V$

Method 2：网孔电流法

We set the meshes as the picture below.

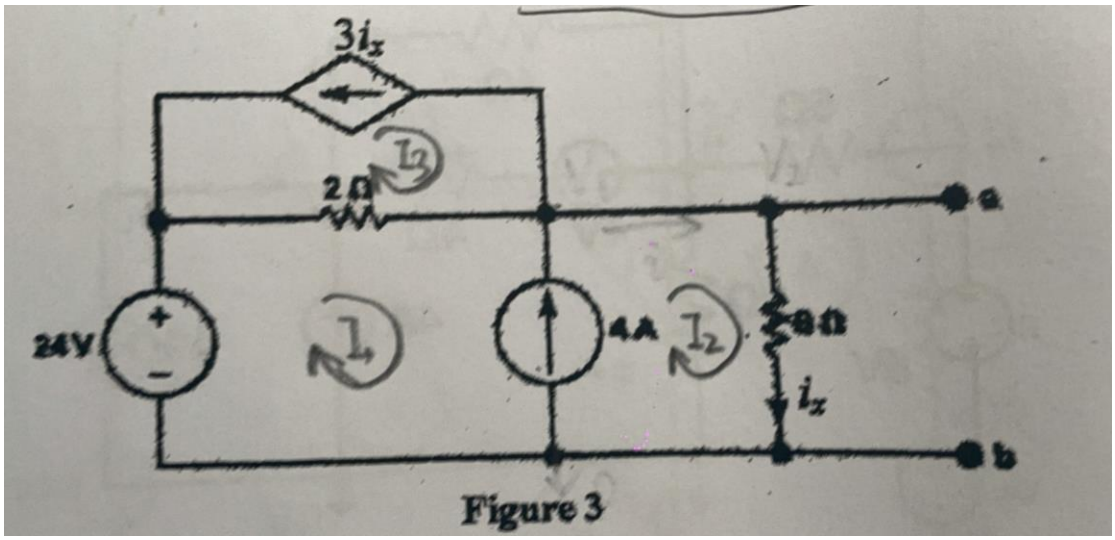


Figure 3

By mesh-current method, we have the equations

$$\begin{cases} 24 - 2(I_1 - I_3) - 8I_2 = 0 \\ -2(I_3 - I_1) + V_{3ix} = 0 \end{cases}$$

Since $4A = I_2 - I_1, I_2 = I_x, I_3 = -3I_x$,we have

$$24 - 2(I_x - 4 + 3I_x) - 8I_x = 0$$

$$32 - 16I_x = 0$$

By solving the equations, we have $I_x = 2A$

Then $V_{TH} = I_x \cdot 8\Omega = 2A \cdot 8\Omega = 16V$

Next, we find the Thevenin equivalent resistor.

Part 2：求解戴维南电阻R_{Th}

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

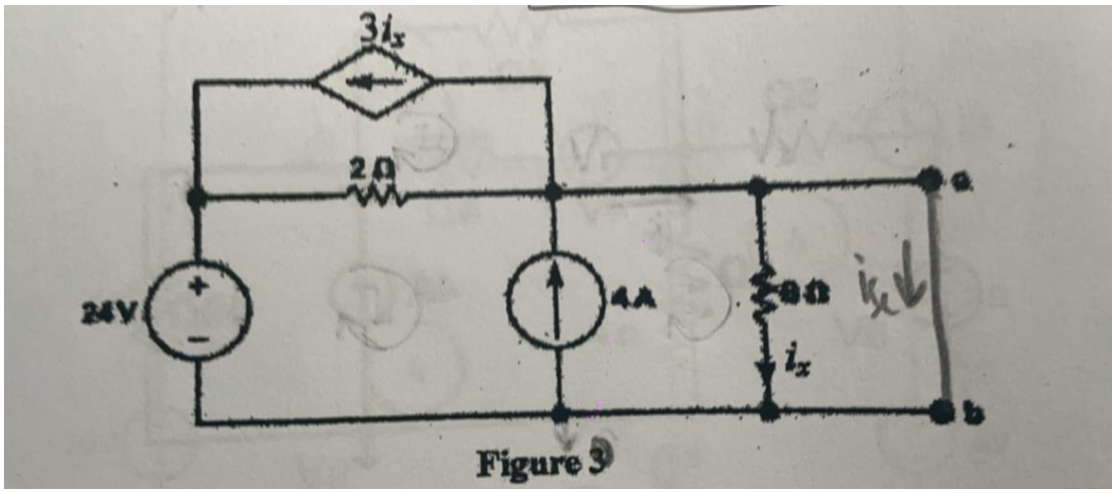


Figure 3

（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:

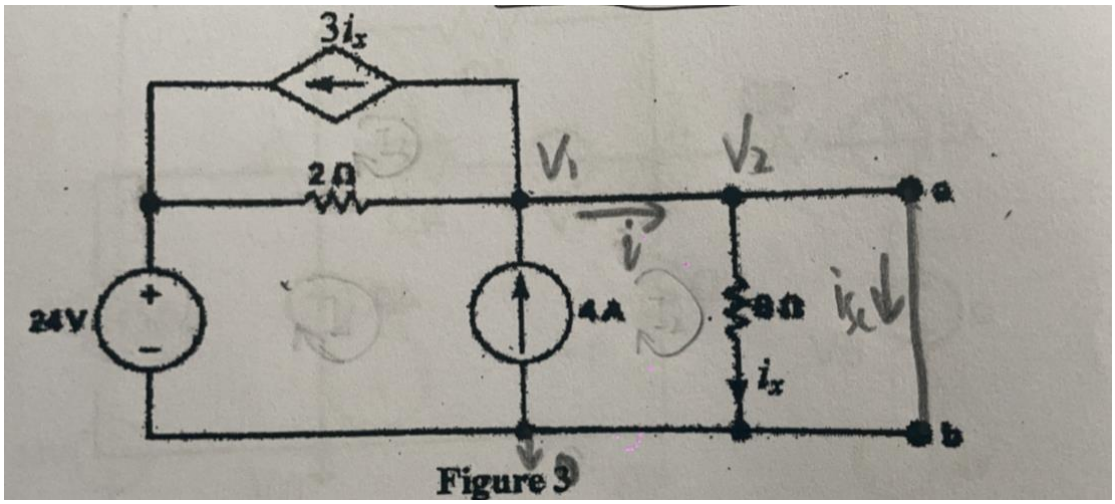


Figure 3

We have the equations:

$$\begin{cases} \dfrac{v_1 - 24}{2} + i - 4 + 3i_x = 0 \\ i_x - i + i_{sc} = 0 \end{cases}$$

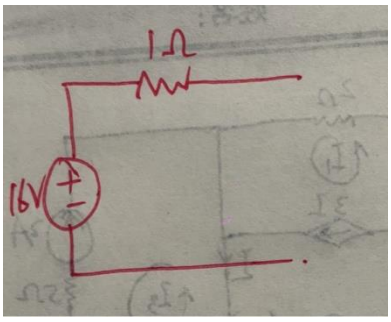
Since $i_x = \frac{v_a}{8}, v_1 = v_a, v_b = 0$, then we have

$$\begin{cases} \dfrac{v_1 - 24}{2} - 4 + i + \dfrac{3v_a}{8} = 0 \\ \dfrac{v_a}{8} - i + i_{sc} = 0 \end{cases}$$

Since $v_b = v_a$, then $v_b = v_a = v_1 = 0$, By solving the equations, we have

$$\begin{cases} i = 16A \\ i_{sc} = 16A \end{cases}$$

Then $R_{TH} = \frac{V_{th}}{Isc} = \frac{16V}{16A} = 1\Omega$



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 V_0.

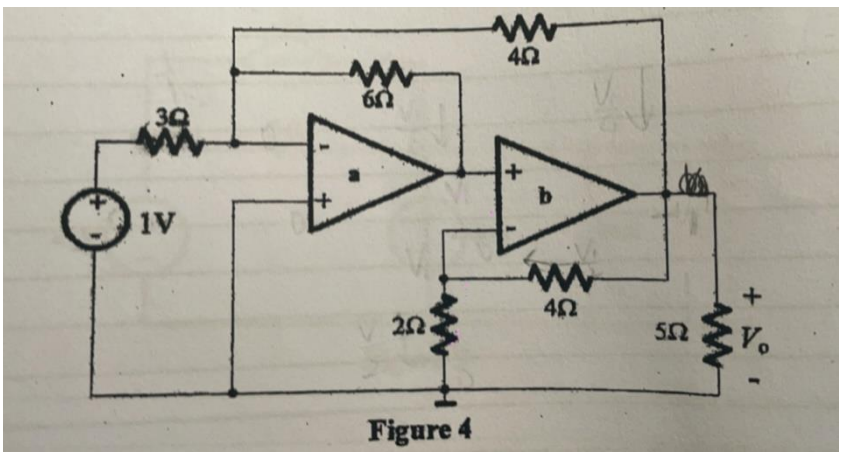


Figure 4

【考点 Point】

运算放大器 Op amp

Answer: $-\frac{12}{11}V$.

【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~

级联注意各放大器之间电压数值的联系。

Solution:

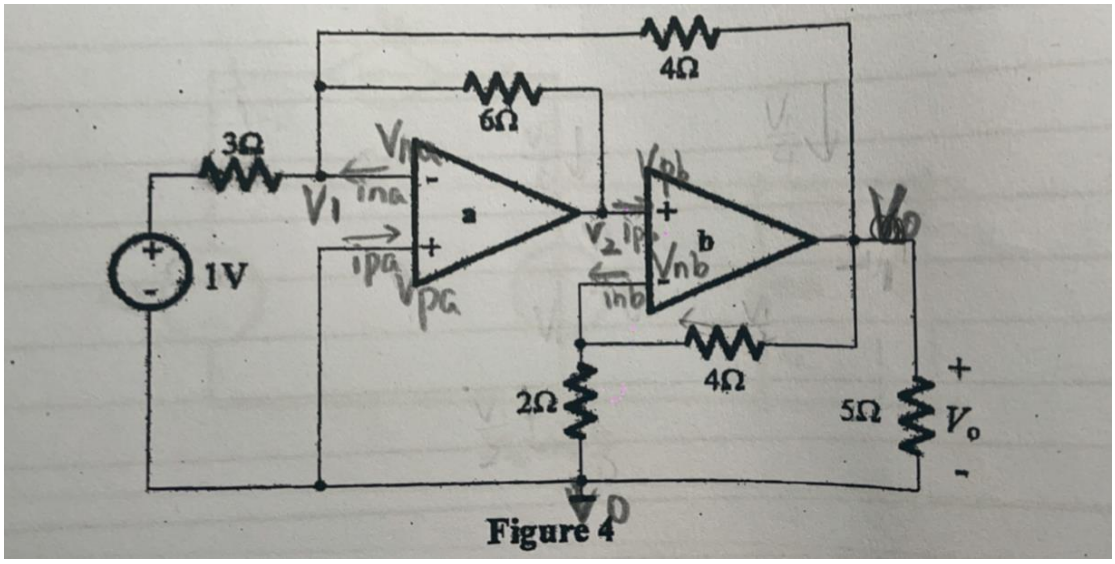


Figure 4

$$v_{pa} = v_{na} = 0V,\ v_{pb} = v_{nb}.$$

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

（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, $v_1 = v_{na} = 0V, v_{pb} = v_{nb} = v_2$.

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

$$\begin{cases} \dfrac{v_1-1}{3}+\dfrac{v_1-v_2}{6}+\dfrac{v_1-v_0}{4}=0 \\ \dfrac{v_2-v_0}{4}+\dfrac{v_2}{2}=0 \end{cases}$$

That is,

$$\begin{cases} \dfrac{3}{4}v_1-\dfrac{1}{6}v_2-\dfrac{1}{4}v_0-\dfrac{1}{3}=0 \\ \dfrac{3}{4}v_2-\dfrac{1}{4}v_0=0 \end{cases} \quad \text{->} \quad \begin{cases} \dfrac{1}{6}v_2+\dfrac{1}{4}v_0=-\dfrac{1}{3} \\ \dfrac{3}{4}v_2-\dfrac{1}{4}v_0=0 \end{cases}$$

By solving the equations, we have

$$\begin{cases} v_2=-\dfrac{4}{11}V \\ v_0=-\dfrac{12}{11}V \end{cases}$$

Finish.

Question 5 (12 Marks): The switch in the circuit in Figure 5 has been opened for a long time. At $t=0$ the seitch is closed. Find $v_L(t)$ for $t \geq 0^+$.

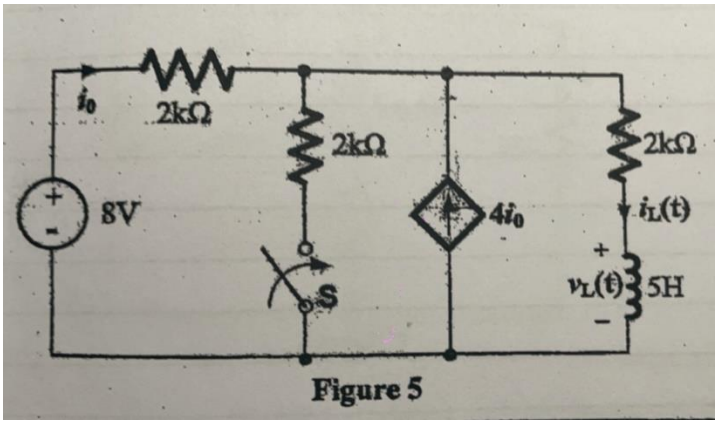


Figure 5

【考点 Point】

自然响应 Natural Responses in an RC circuit.

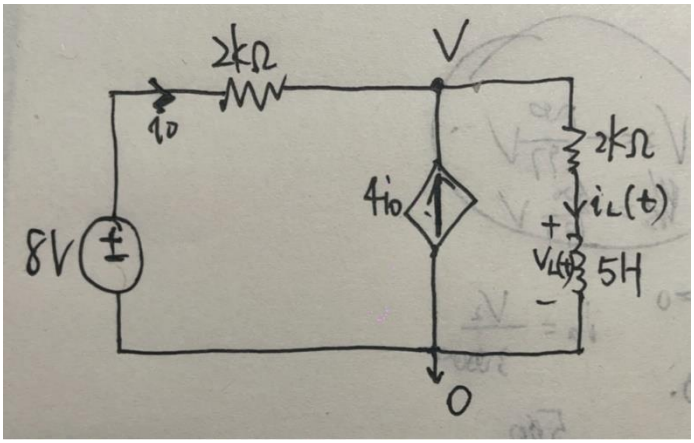
Answer: $\boldsymbol{v_L(t) = -\frac{70}{9}e^{-\frac{1400}{3}t}(t \geq 0^+)}$.

【解析 Analysis】

本题考察电感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+电感，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感的电压随时间变化的函数。

Solution:

When $t < 0$,



$$i_L(0) = 5i_0$$

$$\frac{v-8}{2000} - 4i_0 + \frac{v}{2000} = 0$$

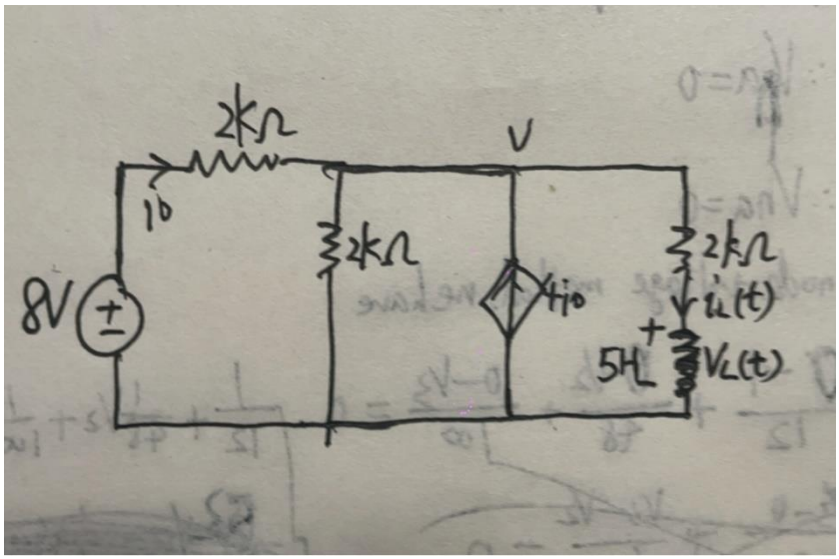
$$i_0 = \frac{8-v}{2000}$$

$$\frac{6v-40}{2000} = 0$$

$$v = \frac{20}{3}V$$

$$i_L(0) = \frac{v}{2000} = \frac{1}{300}A$$

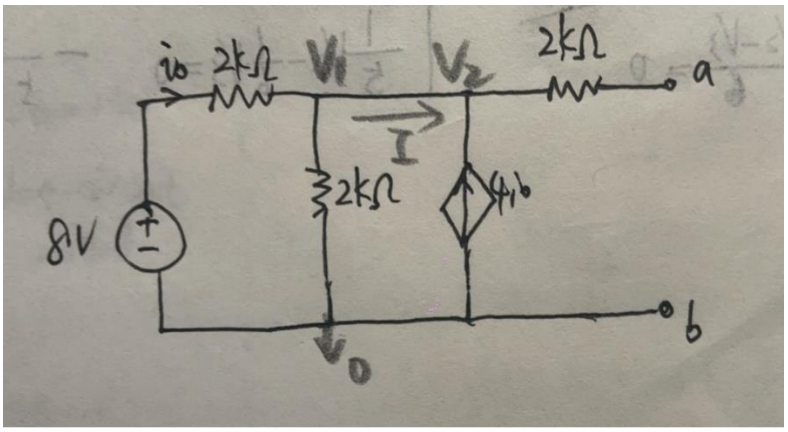
Then we find the Thevenin equivalent circuit at $t > 0$.



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

$$\begin{cases} \dfrac{v_1}{2000} + I + \dfrac{v_1 - 8}{2000} = 0 \\ -I - 4i_0 = 0 \end{cases}$$

By solving the equations, we have

$$\frac{v_1}{2000} + \frac{v_1 - 8}{2000} - 4i_0 = 0$$

$$\frac{v_1}{1000}-\frac{1}{250}-4i_0=0$$

Since $i_0=\frac{8-v_1}{2000}$, then

$$\frac{v_1}{1000}-\frac{1}{250}-4\left(\frac{8-v_1}{2000}\right)=0$$

$$\frac{3v_1}{1000}-\frac{1}{50}=0$$

$$v_1=\frac{20}{3}V$$

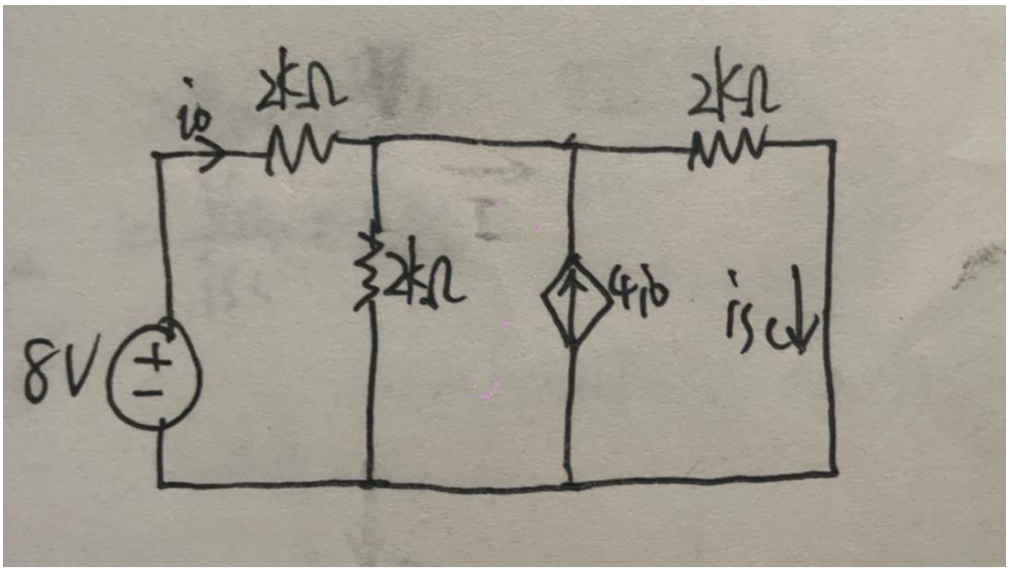
$$v_a=v_1=\frac{20}{3}V, v_b=0V$$

Then $v_{TH}=v_a-v_b=\frac{20}{3}V$

Part 2：求解戴维南电阻R_{Th}

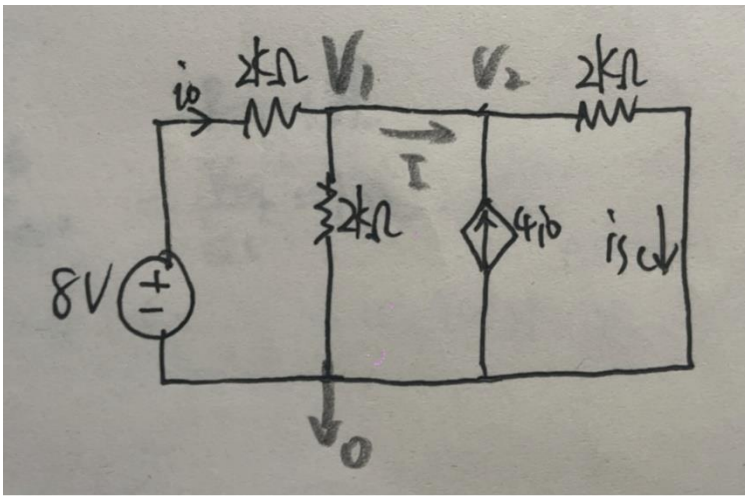
使用短路电流法求解。

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:

$$\begin{cases} \dfrac{v_1}{2000} + I + \dfrac{v_1 - 8}{2000} = 0 \\ -I - 4i_0 + i_{sc} = 0 \end{cases}$$

That is,

$$\frac{v_1}{2000} + \frac{v_1 - 8}{2000} - 4i_0 + i_{sc} = 0$$

Since $i_0 = \frac{8 - v_1}{2000}$, then

$$\frac{v_1}{2000} + \frac{v_1 - 8}{2000} - 4\left(\frac{8 - v_1}{2000}\right) + i_{sc} = 0$$

$$\frac{3v_1}{1000} - \frac{1}{50} + i_{sc} = 0$$

Since $v_a = v_b = 0$, then $i_{sc} = \frac{v_2}{2000}A = \frac{v_1}{2000}A$

By solving the equations, we have

$$\frac{3v_1}{1000} - \frac{1}{50} + \frac{v_1}{2000} = 0$$

$$\frac{7v_1}{2000} - \frac{1}{50} = 0$$

Then, we have $v_1 = \frac{40}{7}V$

$$i_{sc} = \frac{v_1}{2000} = \frac{1}{350} A$$

Then $R_{TH} = \frac{V_{th}}{Isc} = \frac{\frac{20}{3}V}{\frac{1}{350}A} = \frac{7000}{3}\Omega$

Then, the time constant of the capacitance is:

$$\tau = \frac{L}{R_{TH}} = \frac{3}{1400} s$$

Then, the expression of $\boldsymbol{i_L(t)}$ at $t \geq 0^+$ is:

$$\boldsymbol{i_L(t) = \frac{1}{300} e^{-\frac{1400}{3}t} (t \geq 0)}$$

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

$$\boldsymbol{v_L(t) = L\frac{di_L(t)}{dt} = -\frac{70}{9} e^{-\frac{1400}{3}t} (t \geq 0^+)}$$

Finish.

Question 6 (13 Marks): Determine the currents I_1 and I_2 in Figure 6 with node voltage analysis method. The currents can be given by phasor form.

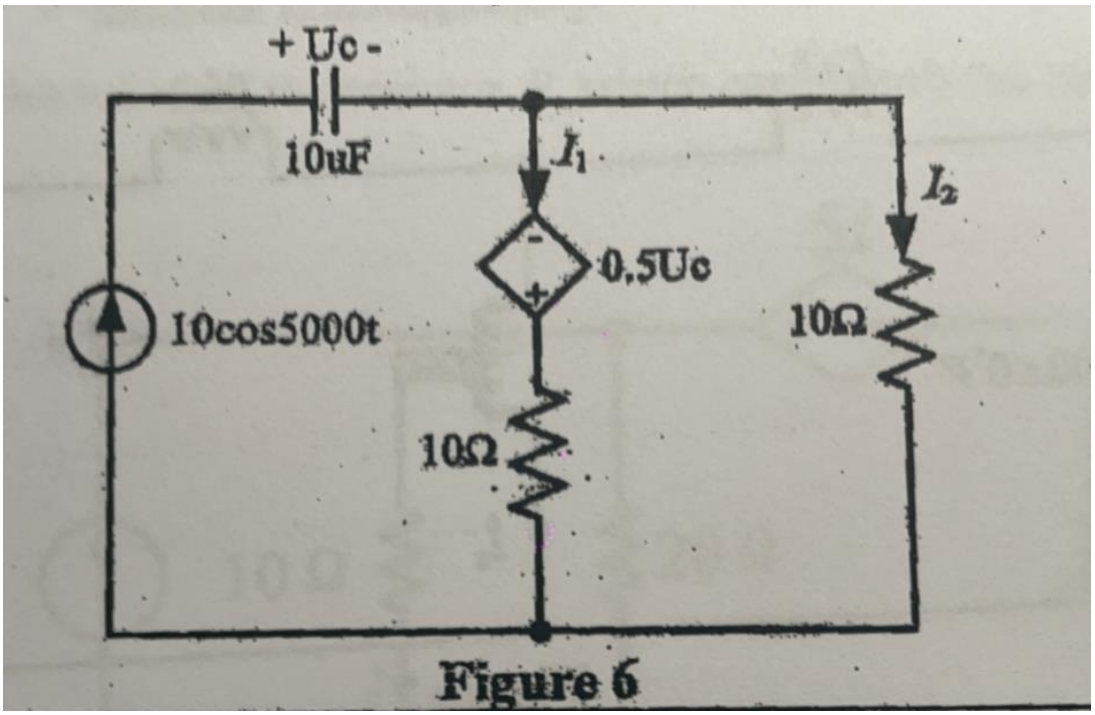


Figure 6

【考点 Point】

正弦稳态分析 The analysis of steady sinusoidal circuit

Answer:

$$i_1 = (5 - 5j)A = 5\sqrt{2}\angle -45°A = 5\sqrt{2}\cos(5000t - 45°)A.$$

$$i_2 = (5 + 5j)A = 5\sqrt{2}\angle 45°A = 5\sqrt{2}\cos(5000t + 45°)A$$

【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.

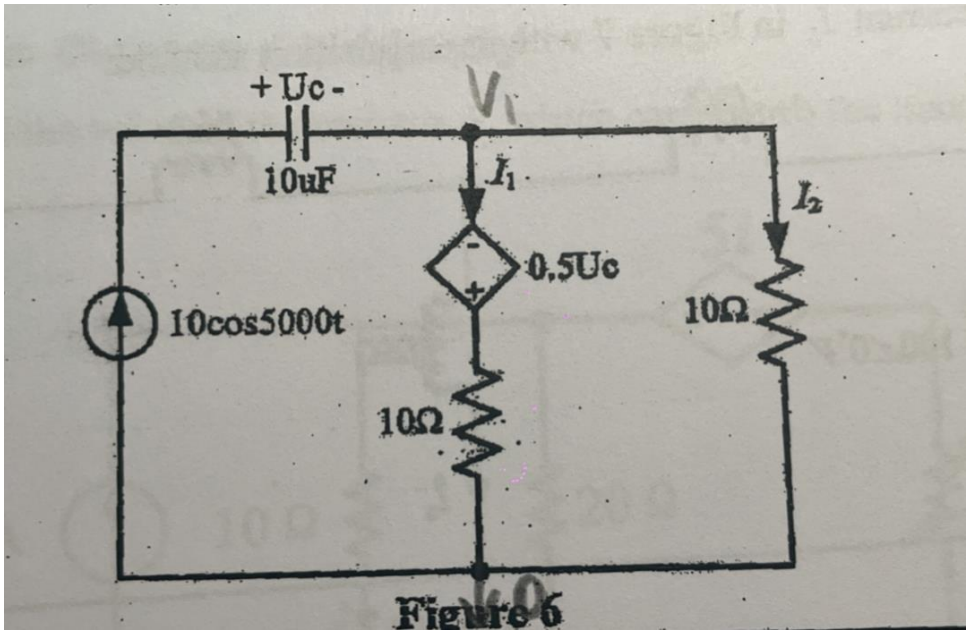


Figure 6

By node-voltage method, we have the equations

$$\frac{v_1 + 0.5U_c}{10} - 10\angle 0° + \frac{v_1}{10} = 0$$

The resistor of the capacitor is:

$$Z_C = \frac{1}{j\omega C} = \frac{1}{j5000 \times 10 \times 10^{-6}} = -j20\Omega$$

Then, we have $U_C = 10\angle 0°A \times (-j20\Omega) = -200jV$

That is,

$$\frac{v_1 - 100jV}{10} - 10\angle 0° + \frac{v_1}{10} = 0$$

$$-10j - 10 + \frac{v_1}{5} = 0$$

Then, we have $v_1 = 50 + 50j$.

Then,

$$i_1 = \frac{v_1 + 0.5U_c}{10} = (5 - 5j)A = 5\sqrt{2}\angle -45°A = 5\sqrt{2}\cos(5000t - 45°)A.$$

$$i_2 = \frac{v_1}{10} = (5 + 5j)A = 5\sqrt{2}\angle 45°A = 5\sqrt{2}\cos(5000t + 45°)A$$

Finish.

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

Determine the phasor current I_0 in Figure 7 with superposition method.

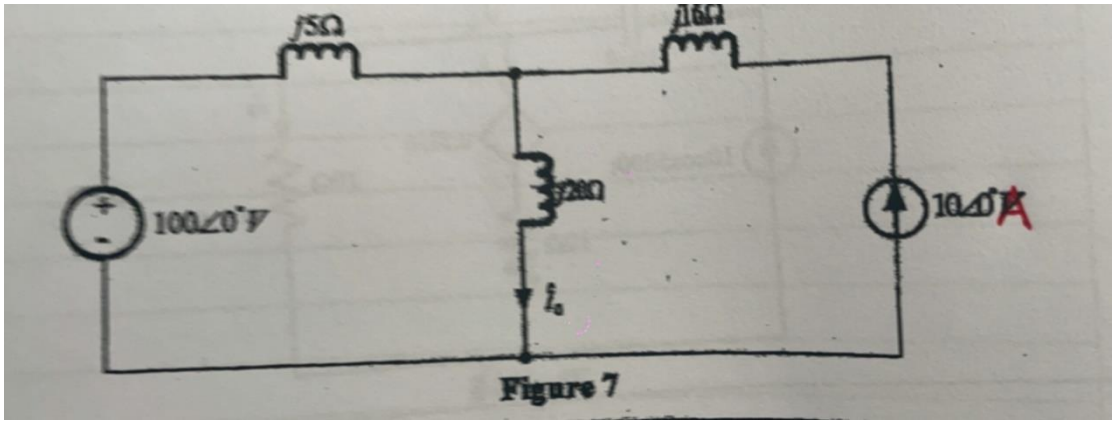


Figure 7

【考点 Point】

叠加法 Superposition Method

Answer: $2-4jA$ / $2\sqrt{5}\angle -63.43°A$ / $2\sqrt{5}cos(\omega t-63.43°)(A)$.

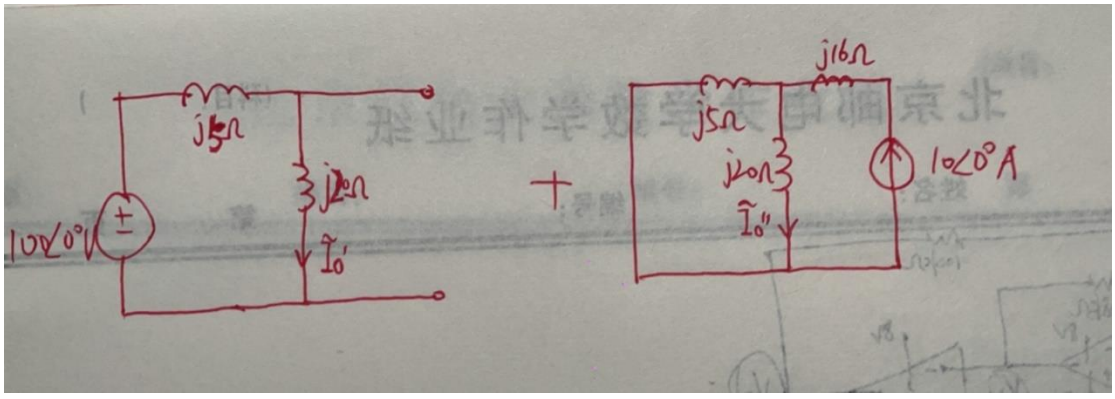
【解析 Analysis】

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I_0进行求解，再把所有的分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 I_0.



$$I_0' = \frac{100\angle 0°}{j5 + j20} + A = j(-4)A$$

$$I_0'' + \frac{j20\Omega}{j5\Omega} I_0'' = 10\angle 0° = 0$$

$$I_0'' = 2\angle 0°A$$

Then,

$$I_0 = I_0' + I_0'' = 2 - 4jA$$

$$I_0 = 2\sqrt{5}\angle -63.43°A$$

$$I_0 = 2\sqrt{5}cos(\omega t - 63.43°)(A)$$

Finish.

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

In the circuit in Figure 8, find the value of the resistor R_L which can absorb the maximum power? And what is the maximum power?

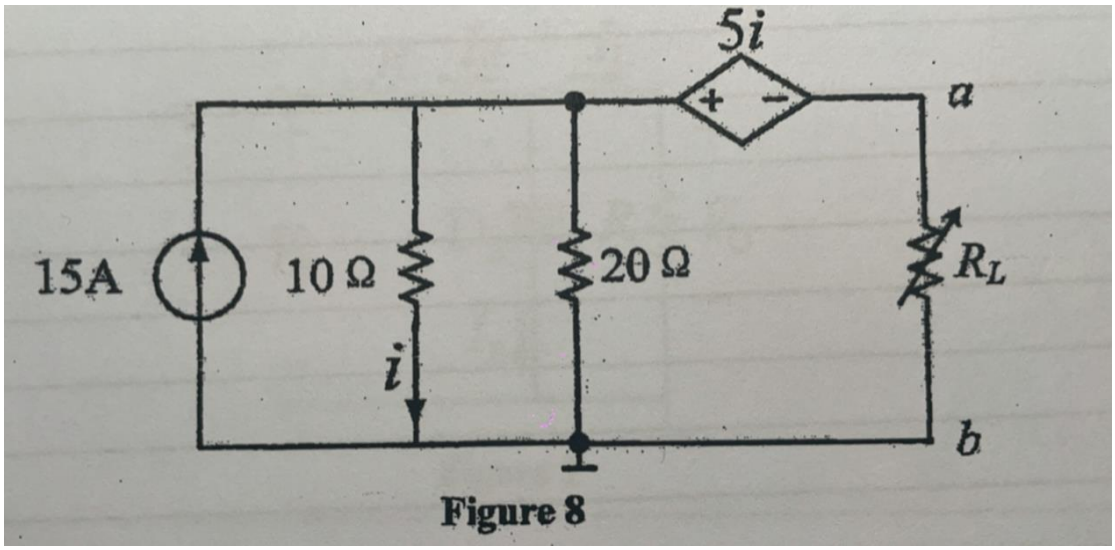


Figure 8

【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: $\frac{10}{3}\Omega$, $187.5W$.

【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.

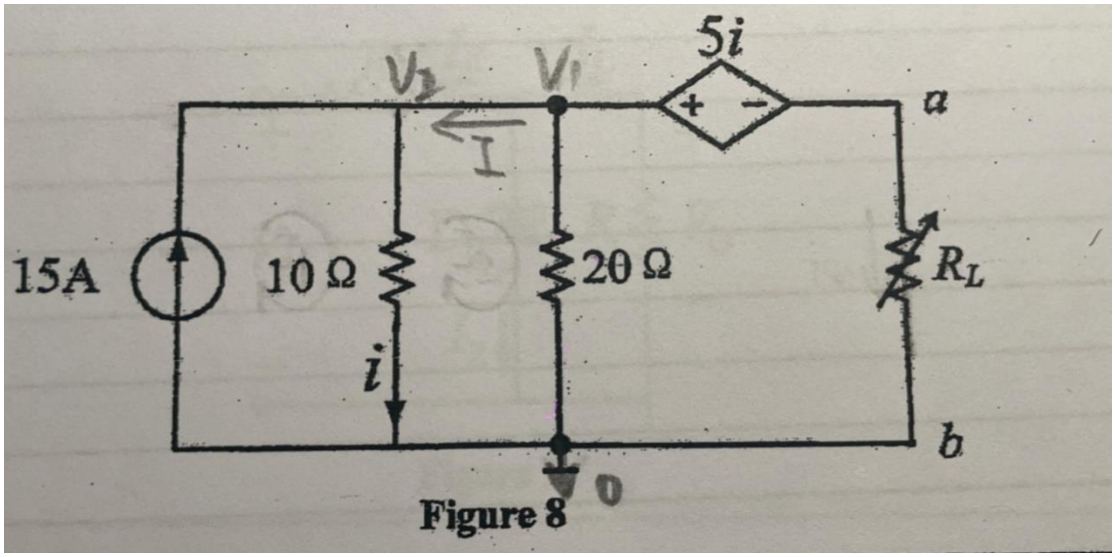


Figure 8

By node-voltage method, we have the equations

$$\begin{cases} \frac{v_1}{20} + I = 0 \\ \frac{v_2}{10} - I - 15 = 0 \end{cases}$$

Since $v_1 = v_2, i = \frac{v_2}{10}$, we have

$$\frac{v_1}{20} + \frac{v_1}{10} - 15 = 0$$

By solving the equations, we have

$$\begin{cases} v_1 = 100V \\ i = \frac{v_2}{10} = \frac{v_1}{10} = 10A \end{cases}$$

Since $v_b = 0V, v_a = v_1 - 5i = 50V$, then

$$v_{TH} = v_a - v_b = 50V - 0V = 50V$$

Method 2：网孔电流法

We set the meshes as the picture below.

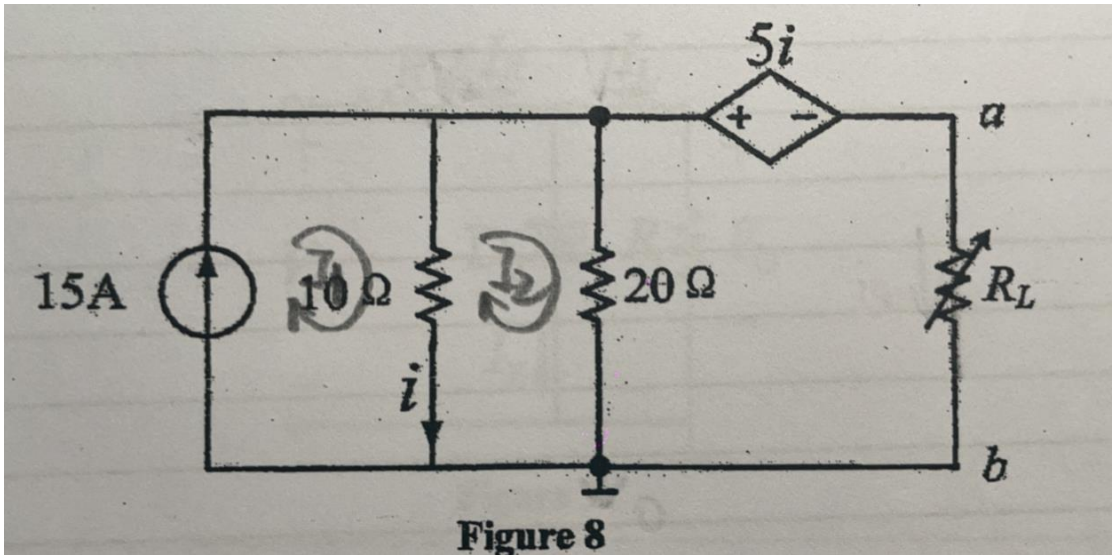


Figure 8

By mesh-current method, we have the equations

$$\begin{cases} V_{15A} - 10(I_1 - I_2) = 0 \\ -10(I_2 - I_1) - 20I_2 = 0 \\ I_1 = 15A \end{cases}$$

By solving the equations, we have

$$\begin{cases} I_1 = 15A \\ I_2 = 5A \end{cases}$$

$$i = I_1 - I_2 = 10A, v_a = v_1 - 5i = 50V.$$

Since $v_b = 0V$ then,

$$v_{ab} = v_1 - 5i - 0 = 50V$$

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:

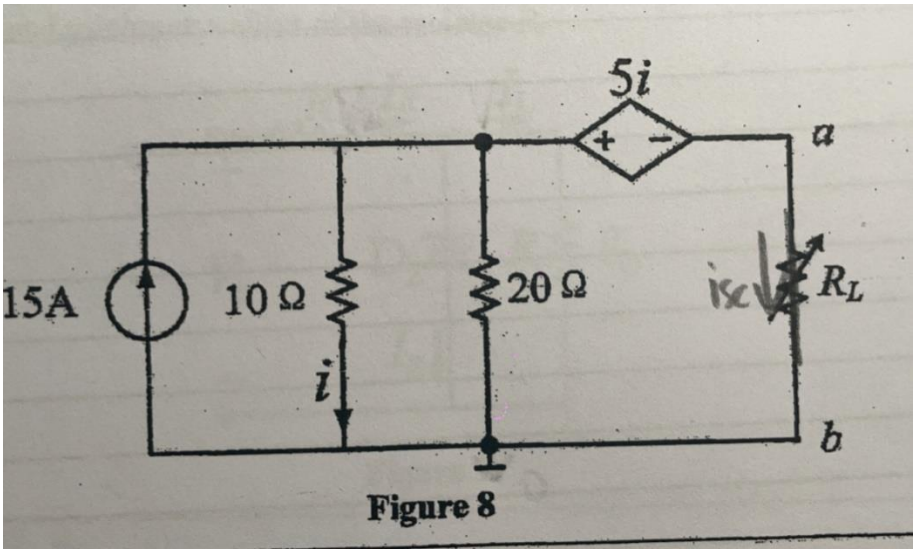


Figure 8

（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:

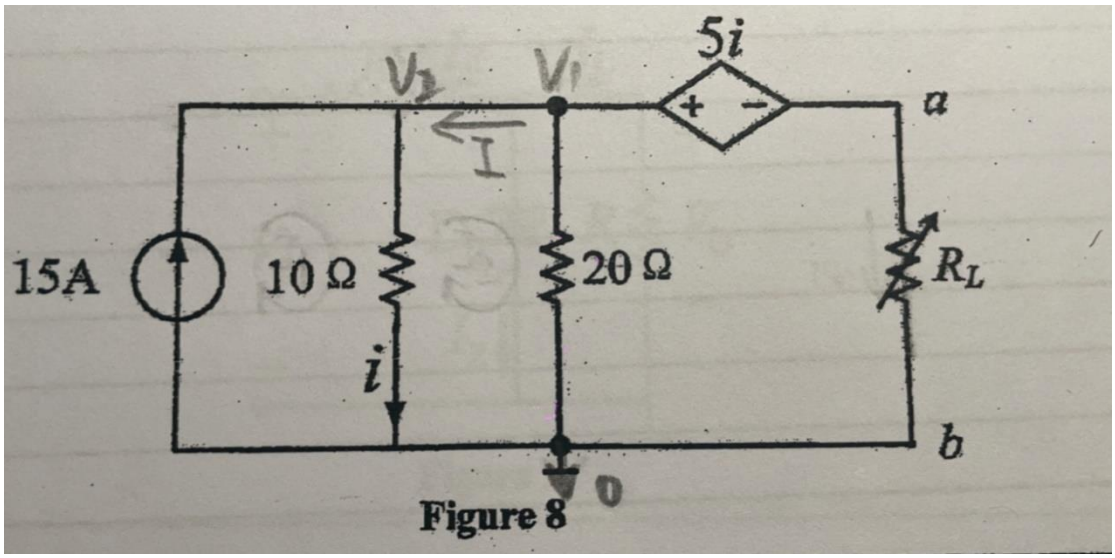


Figure 8

And we have the equations:

$$\begin{cases} \frac{v_1}{20} + I + i_{sc} = 0 \\ \frac{v_2}{10} - I - 15 = 0 \end{cases}$$

Since $v_1 = v_2, i = \frac{v_2}{10}$, we have

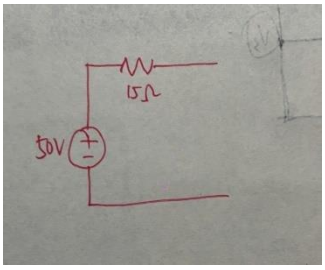
$$\frac{v_1}{20} + \frac{v_1}{10} - 15 + i_{sc} = 0$$

Since $v_a = v_b = 0V$, then $v_1 = 5i = \frac{v_1}{2}$

Then, $v_1 = 0V, i = 0A.$

$$i_{sc} = 15A$$

Then $R_{TH} = \frac{V_{th}}{Isc} = \frac{50V}{15A} = \frac{10}{3}\Omega$



We find the Thevenin equivalent circuit.

When $R_L = R_{TH} = \frac{10}{3}\Omega$, the resistor will absorb the maximum power, and the power is $P_{max} = \frac{(V_{Th})^2}{4R_L} = 187.5W$ Finish.

EEF 部分

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

In the circuit shown in Figure 9, $V_s = 11V$, $R_L = 800\Omega$. For the Zener diode D_Z, the regulation voltage $V_Z = 8V$, the maximum regulation current $I_{Zmax} = 25mA$, and the minimum regulation current $I_{Zmin} = 5mA$. Determine the maximum and minimum values of the resistor R.

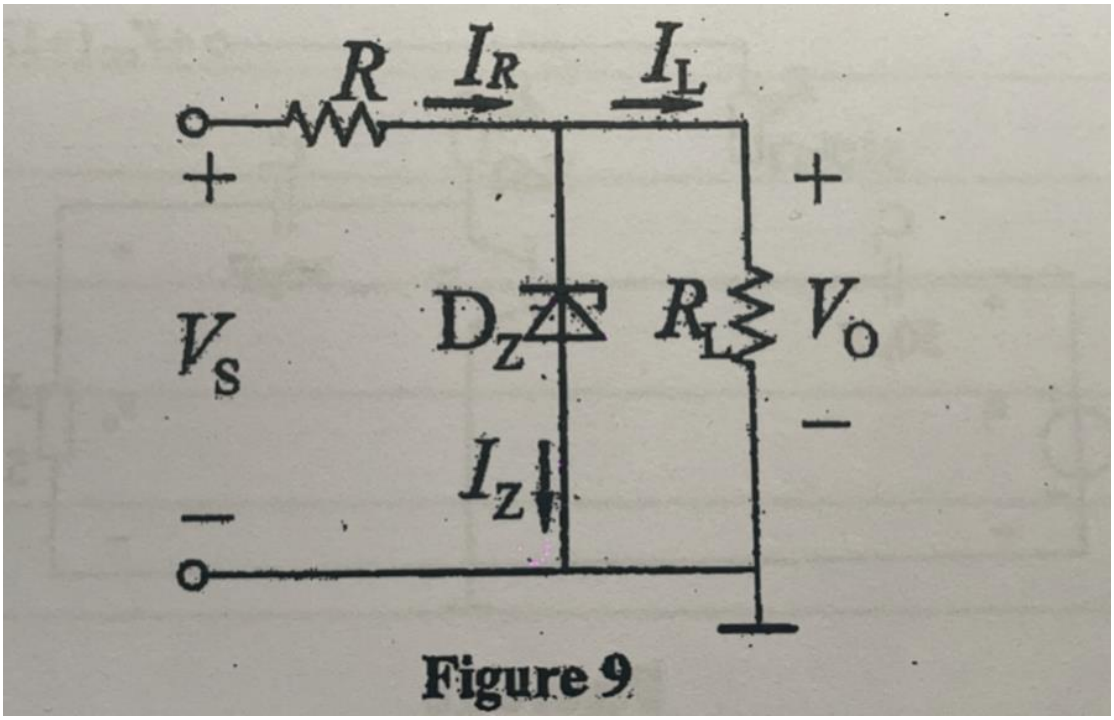


Figure 9

【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: $Max: 200\Omega, Min: 85.71\Omega$.

【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:

$$V_0 = V_Z = 8V$$

The current on the load resistor R_L is: $I_L = \frac{V_0}{R_L} = \frac{8V}{800\Omega} = 10mA$

The voltage of the resistor R is $V_R = V_S - V_0 = 3V$.

The maximum of the current passing the resistor R is:

$$I_{Rmax} = I_L + I_{Zmax} = 10mA + 25mA = 35mA$$

The minimum of the current passing the resistor R is:

$$I_{Rmin} = I_L + I_{Zmin} = 10mA + 5mA = 15mA$$

The maximum of the resistor R is:

$$R_{max} = \frac{V_R}{I_{Rmin}} = \frac{3V}{15mA} = 200\Omega$$

The minimum of the resistor R is:

$$R_{min} = \frac{V_R}{I_{Rmax}} = \frac{3V}{35mA} = 85.71\Omega$$

Finish.

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

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

(1)Asusume $\boldsymbol{\beta = 120}$ and $\boldsymbol{V_{BEQ} = 0.8V}$, 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 $\boldsymbol{A_v}$. $\boldsymbol{(V_T = 26mV)}$ 原题目有误!!

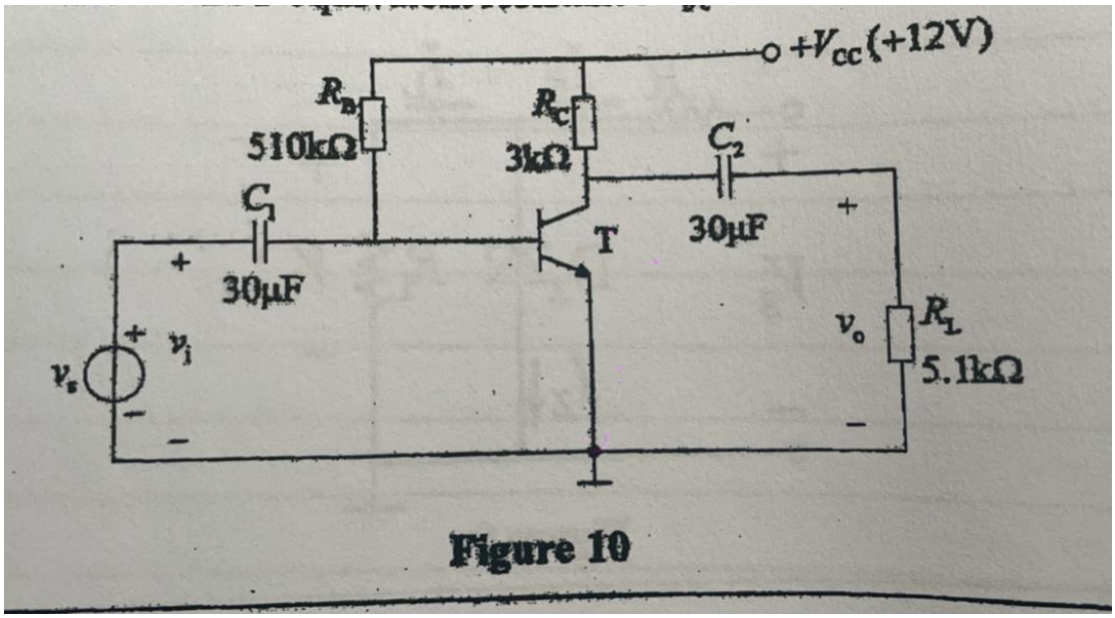


Figure 10

【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

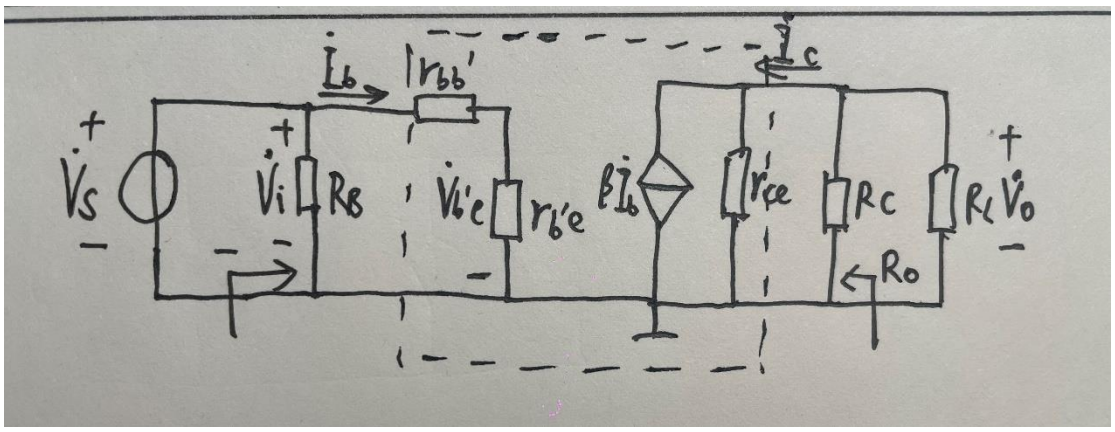
交流动态分析 Dynamic analysis

Answer:

(1) $I_{BQ} = 22.0\mu A, I_{CQ} = 2.64mA, V_{CEQ} = 4.08V$

(2) $r_{b'e} \approx 1.18(k\Omega), A_V \approx -192.2$

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)

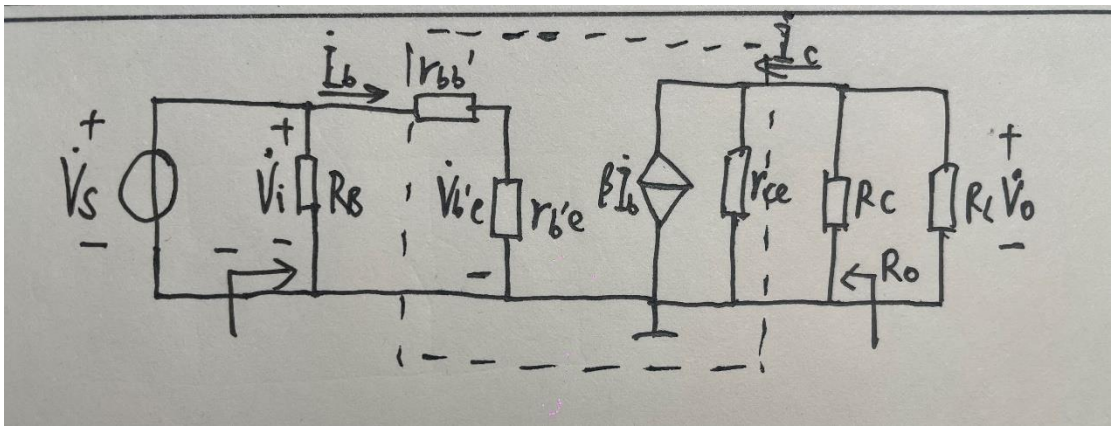
$$I_{BQ} = \frac{V_{CC} - V_{BEQ}}{R_B} = \frac{12V - 0.8V}{510k\Omega} = 22.0\mu A$$

$$I_{CQ} = \beta I_{BQ} = 2.64mA$$

$$V_{CEQ} = V_{CC} - I_{CQ}R_C = 12V - 2.64mA \times 3k\Omega = 4.08V$$

(2)

The small-signal hybrid-π equivalent circuit is:



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

$$r_{b\prime e} = \frac{V_T}{I_{BQ}} = \frac{26mV}{22.0 \times 10^{-3}mA} \approx 1.18(k\Omega)$$

Next, we find the voltage gain.

$$r_{be} = r_{bb'} + r_{b'e} = r_{bb'} + \frac{V_T}{I_{BQ}} = 0 + \frac{V_T}{I_{BQ}} \approx 1.18(k\Omega)$$

Total resistor load is:

$$R_L' = r_{ce} \left|\right| R_c \left|\right| R_L = 1.89(k\Omega)$$

The voltage gain A_v is:

$$A_V = \frac{V_0}{V_i} = -\frac{\beta {R_L}'}{r_{be}} \approx -192.2$$

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