课程编号：101051247　北京理工大学 2022 — 2023 学年 第 二 学期

2022 级 电路分析基础（全英文） 课程试卷 A

参考答案和评分标准

开课学院： 集成电路与电子学院　　　任课教师： 邓小英

试卷用途：☐期中　☑期末　☐补考　☐重修

考试形式：☐开卷　☐半开卷　☑闭卷

考试日期： 2023 年 5 月 23 日　　　所需时间： 120 分钟

考试允许带： 计算器和必要的文具 入场

班级：________ 学号：________ 姓名：________

考生承诺：“我确认本次考试是完全通过自己的努力完成的。”

考生签名：

题序	1	2	3	4	5	6	7	8	9	总分
满分	10	12	12	12	10	12	12	10	10	100
得分										

注意：

1. 试题共 9 题，共 6 页（包含此页）；
2. 所有试题答案都写在相应空白位置处，要写清过程，结果若为小数需保留 1 位小数。

1. (10 points) For the circuit shown in Fig.1,

(1) Find v_a and v_b ;

(2) If a 10Ω resistor is connected between a and b, find i_{ab}.

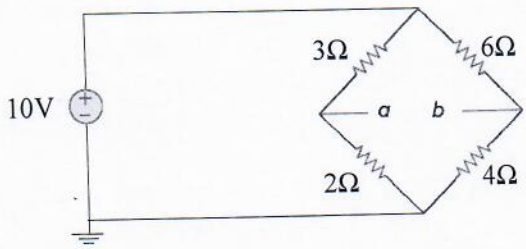


Fig.1

(1) $v_a = \frac{2}{2+3} \times 10 = 4V$ 3分

$v_b = \frac{4}{6+4} \times 10 = 4V$ 3分

(2) ∵ $v_a = v_b$, $R_{ab} = 10\Omega$

∴ $i_{ab} = \frac{0}{10} = 0\ A$ 4分

2. (12 points) For the circuit shown in Fig.2,

(1) find v_o by the nodal analysis ;

(2) calculate the power developed by the dependent source, and determine whether the power is supplied or absorbed.

(1) Add the reference node as shown in Fig.2

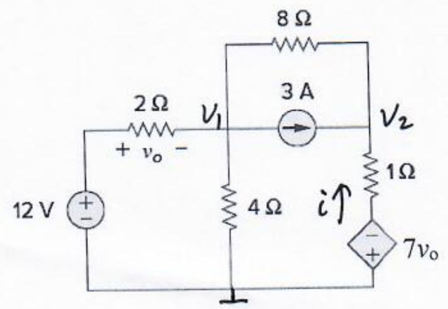


Fig.2

$$\begin{cases} \frac{v_1}{4} + \frac{v_1 - 12}{2} + 3 + \frac{v_1 - v_2}{8} = 0 & 2分 \\ \frac{v_2 - (-7v_o)}{1} - 3 + \frac{v_2 - v_1}{8} = 0 & 2分 \\ 12 - v_1 = v_o & 2分 \end{cases}$$

∴ $v_o = 84\ V$, $v_2 = 60 - 7v_o = -528V$
2分

(2) $i = \frac{-7v_o - v_2}{1} = -7 \times 84 - (-528) = -60A$ 1分

$P = 7v_o \cdot i = -35280\ W$ 2分

supply power 1分

3. (12 points) In the steady-state circuit shown in Fig.3, $v_S(t) = 12\cos\omega t$ V.

(1) Find and draw the Norton equivalent of the left-part circuit from terminals ab;

(2) Find the resonant frequency ω_0, the quality factor Q and bandwidth B as seen by the inductor;

(3) Find the cut-off frequencies ω_1, ω_2 and the average power dissipated at ω_0, ω_1, ω_2.

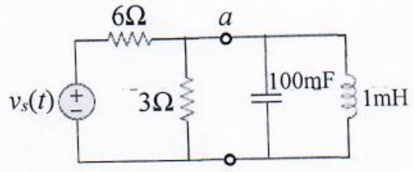


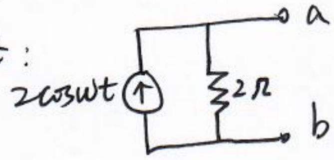
Fig. 3

(1) As seen from terminals ab

$R_0 = 3 \| 6 = 2\,\Omega$ 2分

$i_{sc} = \frac{V_s(t)}{6} = 2\cos\omega t$ A 2分

Norton equivalent:



1分

(2) $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{10^3}{10} = 100$ rad/s 1分

$B = \frac{G}{C} = \frac{1}{R_0 C} = \frac{10}{2} = 5$ rad/s 1分

$Q = \frac{\omega_0}{B} = \frac{100}{5} = 20$ 1分

(3) $\omega_1 = 100 - \frac{5}{2} = 97.5$ rad/s 1分

$\omega_2 = 100 + \frac{5}{2} = 102.5$ rad/s 1分

$P_{\omega_0} = I_{rms}^2 R_0 = \left(\frac{2}{\sqrt{2}}\right)^2 \cdot 2 = 4$ W 1分

$P_{\omega_1} = P_{\omega_2} = \frac{1}{2} P_{\omega_0} = 2$ W 1分

4. (12 points) The switch in Fig.4 has been open for a long time, and is open at $t = 0$.

(1) Determine $i(0^+)$, $v(0^+)$, $\frac{di(0^+)}{dt}$ and $\frac{dv(0^+)}{dt}$;

(2) For $t > 0$, write the second-order circuit equation about $v(t)$ and determine what type of damping this circuit exhibits (over-damped/under-damped/critically-damped).

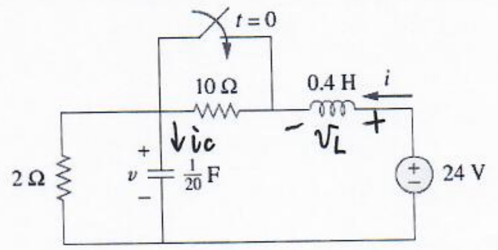


Fig.4

(1) $i(0^+) = i(0^-) = \frac{24}{12} = 2A$ 1分

$v(0^+) = v(0^-) = 2A \times 2\Omega = 4V$ 1分

$v_L(0^+) = 24 - v(0^+) = 20$ V

$\therefore \left.\frac{di}{dt}\right|_{t=0^+} = \frac{v_L(0^+)}{L} = 50$ A/s 2分

$i_C(0^+) = i - \frac{v(0^+)}{2} = 2 - \frac{4}{2} = 0$

$\therefore \left.\frac{dv}{dt}\right|_{t=0^+} = \frac{i_C(0^+)}{C} = 0$ 2分

(2) $\begin{cases} \frac{v}{2} + \frac{1}{20}\frac{dv}{dt} = i & ① \\ 0.4\frac{di}{dt} = 24 - v & ② \end{cases}$ 1分 1分

Take the derivative of ①:

$\frac{1}{2}\frac{dv}{dt} + \frac{1}{20}\frac{d^2v}{dt^2} = \frac{di}{dt}$ ③ 2分

Substitute ③ into ②: $\frac{d^2v}{dt^2} + 10\frac{dv}{dt} + 50v = 1200$

$\therefore$ characteristic equation $s^2 + 10s + 50 = 0$

$\Delta = 10^2 - 4 \times 50 = -100 < 0$ 1分

$\therefore$ under-damped case. 1分

5. (10 points) For the circuit in Fig.5, what resistor connected across terminals *a*-*b* will absorb maximum power from the circuit? What is the maximum power?

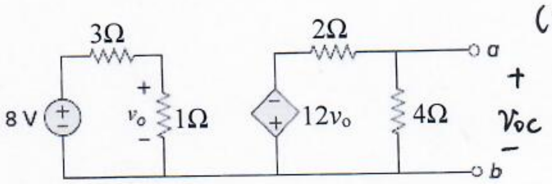


Fig.5

(1) Find the Thevenin equivalent from ab:

$v_o = \frac{1}{1+3}\times 8 = 2V$

$v_{oc} = -12v_o \times \frac{4}{2+4} = -24\times\frac{2}{3} = -16V$ 3分

$i_{sc} = -\frac{24}{2} = -12A$

$R_o = \frac{-16}{-12} = \frac{4}{3}\Omega$ 3分

or $R_o = 2 // 4 = \frac{4}{3}\Omega$

(2) When $R_L = \frac{4}{3}\Omega$, 2分

$P_{max} = \frac{V_{oc}^2}{4R_o} = \frac{16^2}{4\times\frac{4}{3}} = 48W$ 2分

6. (12 points) In the steady-state ciucuit shown in Fig.6, $u_s(t) = 2\cos(1000t+30^\circ)$. Calculate the steady-state response $i(t)$.

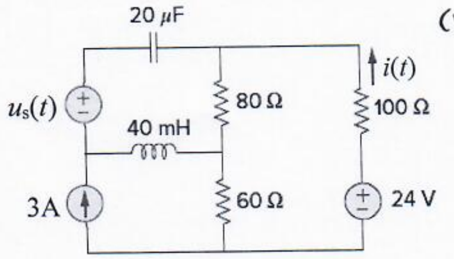
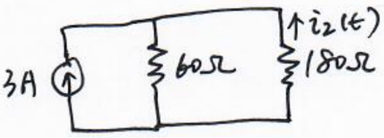


Fig.6

(1) 24V acting alone:

$i_1(t) = \frac{24}{100+80+60} = \frac{24}{240} = 0.1A$ 3分

(2) 3A acting alone:



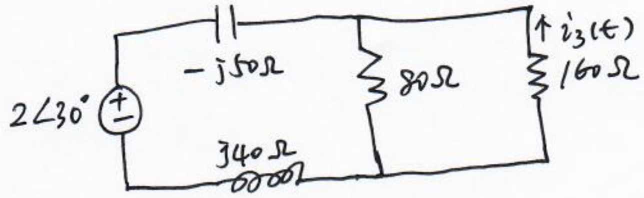
$i_2(t) = -3\times\frac{60}{60+180}$

$= -\frac{3}{4}A$ 3分

(3) $u_s(t) = 2\cos(1000t+30^\circ)$ acting alone:

$j\omega L = j1000\times 40\times 10^{-3} = j40\Omega$

$-j\frac{1}{\omega C} = -j\frac{1}{1000\times 20\times 10^{-6}} = -j50\Omega$



$\dot{I}_3 = \frac{80}{160+80}\times\frac{-2\angle 30^\circ}{j40-j50+80//160}$

$= \frac{1}{3}\times\frac{2\angle -150^\circ}{\frac{160}{3}-j10}$

$= \frac{2\angle -150^\circ}{160-j30} = \frac{2\angle -150^\circ}{162.8\angle -10.6^\circ}$

$= 0.012\angle -139.4^\circ$ A 4分

$\therefore i_3(t) = 0.012\cos(1000t-139.4^\circ)$ A

$\therefore i(t) = -0.65 + 0.012\cos(1000t-139.4^\circ)$ A

2分

7. (12 points) Refer to the circuit shown in Fig.7,

(1) What is the power factor of the load Z ? Is it a lagging or leading pf ?

(2) What are the average power and the reactive power developed by the load Z ?

(3) What element should be connected with the load Z that will raise the power factor to 0.95? Calculate the value of the capacitance (if the element is a capacitor) or the inductance (if the element is an inductor).

Fig. 7

(1) $pf = \cos\theta = \frac{3}{\sqrt{3^2+4^2}} = \frac{3}{5}$, lagging pf , inductive load
2   1

(2) $P = \left|\frac{120}{5}\right|^2 \times 3 = 24^2 \times 3 = 1728\ W$ 2

$Q = \left|\frac{120}{5}\right|^2 \times 4 = 2304\ VAR$ 2

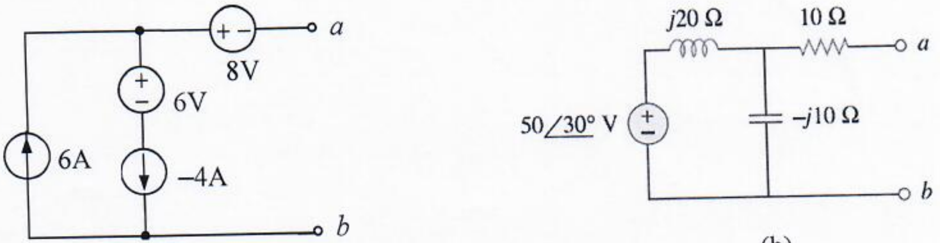
(3) Capacitor   1

$Q_2 = P \cdot \tan\theta_2 = 1728 \times \frac{\sqrt{1-0.95^2}}{0.95} = 563.9\ VAR$ 1

$Q_C = 563.9 - 2304 = -1740.1 = -\omega C V^2 = -2\pi \times 60 \times C \times 120 \times 120$ 2

$C = \frac{-1740.1}{-120\pi \times 120 \times 120} = 0.32\,mF = 321\,\mu F$ 1

8. (10 points) Simplify the following two-terminal networks in Fig.8.



(a) (b)

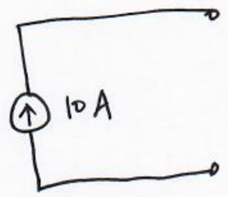
Fig.8

(b) $\dot{V}_{oc} = 50\angle 30^\circ \times \dfrac{-j10}{j20 - j10} = 50\angle -150^\circ$ V 2分

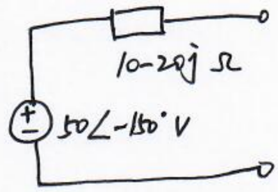
$Z_0 = 10 + j20 \parallel (-j10)$ 2分

$= 10 + \dfrac{20\times 10}{j10} = 10 - 20j$

(a)



5分



1分

9. (10 points) In the circuit shown in Fig.9, the switch has been open for a long time, and is closed at t =0, find the capacitor voltage $v(t)$ for $t > 0$.

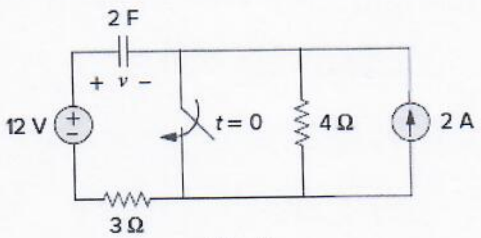


Fig.9

$t<0$, $V(0_-) = 12 - 4\times 2 = 4V = V(0_+)$ 2分

$t\to\infty$, $v(\infty) = 12V$ 2分

$R_0 = 3\ \Omega \Rightarrow \tau = R_0 C = 6$ s 2分

$v(t) = v(\infty) + [v(0_+) - v(\infty)]e^{-\frac{t}{\tau}}$ 2分

$= 12 - 8e^{-\frac{t}{6}}$ V, $t>0$ 2分