Benha University

Benha Faculty of Engineering

January, 2017

Exam

Examiner: *Dr. Wael A. Mohamed*

Department: Electrical Engineering

Time: 3 Hours.

B. Sc. Course Exam

Subject: Elec. Eng. And Circuit Analysis (a)

E1101

Question ❶ (***10 marks***)

In the circuit in Fig.1. Use the Y ⇔ Δ transformations to find the total resistance between a and b terminals.

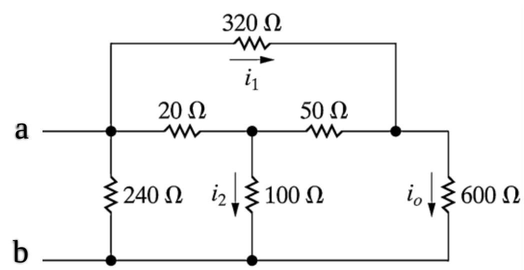
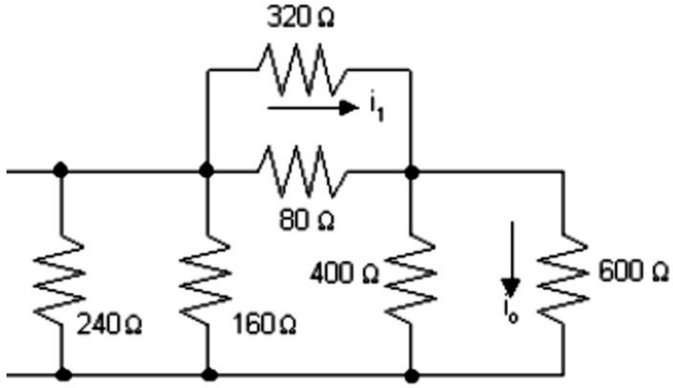
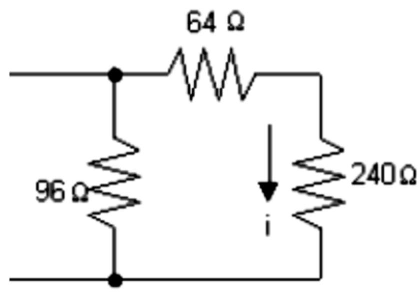


Fig.1

After the 20 Ω—100 Ω—50 Ω wye is replaced by its equivalent delta, the circuit reduces to



Now the circuit can be reduced to



Then the equivalent circuit is the 96 ohm in parallel with (64+240)

Question ❷ (***20 marks***)

For the circuit shown in Fig.2,

a) Write the node voltage equations needed to find the currents $\boldsymbol{i_a}$ to $\boldsymbol{i_e}$. (***Write both the main equations and the auxiliary equations***).

b) Write the mesh current equations needed to find the currents $\boldsymbol{i_a}$ to $\boldsymbol{i_e}$. (***Write both the main equations and the auxiliary equations***).

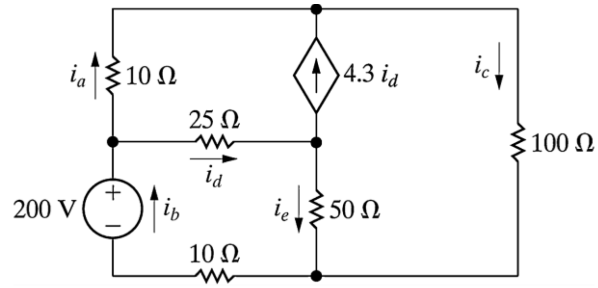
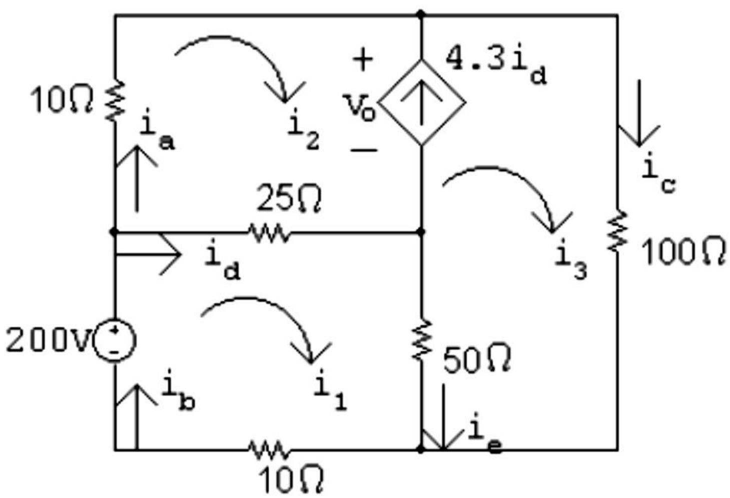


Fig.2

a) Write the node equations by yourself.

b) Only needed the mesh equations



$$200 = 85i_1 - 25i_2 - 50i_3$$

$$0 = -75i_1 + 35i_2 + 150i_3 \qquad \text{(supermesh)}$$

$$i_3 - i_2 = 4.3(i_1 - i_2)$$

Solving, $i_1 = 4.6$ A; $\quad i_2 = 5.7$ A; $\quad i_3 = 0.97$ A

$i_a = i_2 = 5.7$ A; $\quad i_b = i_1 = 4.6$ A

$i_c = i_3 = 0.97$ A; $\quad i_d = i_1 - i_2 = -1.1$ A

$i_e = i_1 - i_3 = 3.63$ A

<u>Question ❸</u> (***20 marks***)

The variable resistor $\boldsymbol{R_L}$ in the circuit shown in Fig.3 is adjusted for maximum power transfer to $\boldsymbol{R_L}$.

a) Find the numerical value of $\boldsymbol{R_L}$.
b) Find the maximum power transferred to $\boldsymbol{R_L}$.
c) Find the value of $\boldsymbol{R_L}$ if the power transferred to it is 24 Watt.

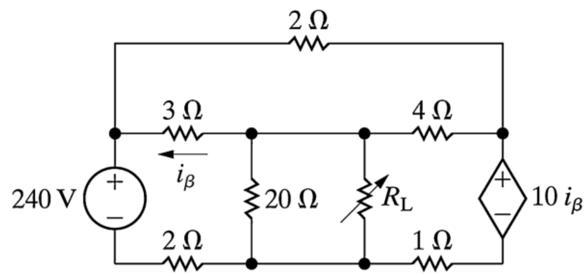
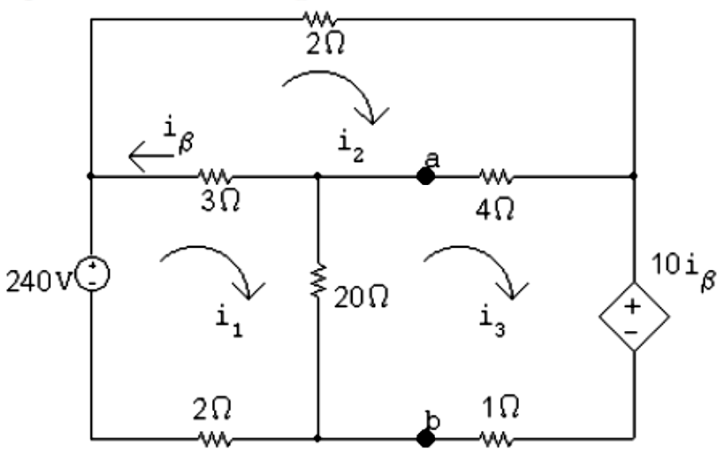


Fig.3

[a] Find the Thévenin equivalent with respect to the terminals of R_L.

Open circuit voltage:



The mesh current equations are:

$$
\begin{aligned}
-240 + 3(i_1 - i_2) + 20(i_1 - i_3) + 2i_1 &= 0 \\
2i_2 + 4(i_2 - i_3) + 3(i_2 - i_1) &= 0 \\
10i_\beta + 1i_3 + 20(i_3 - i_1) + 4(i_3 - i_2) &= 0
\end{aligned}
$$

The dependent source constraint equation is:

$i_\beta = i_2 - i_1$

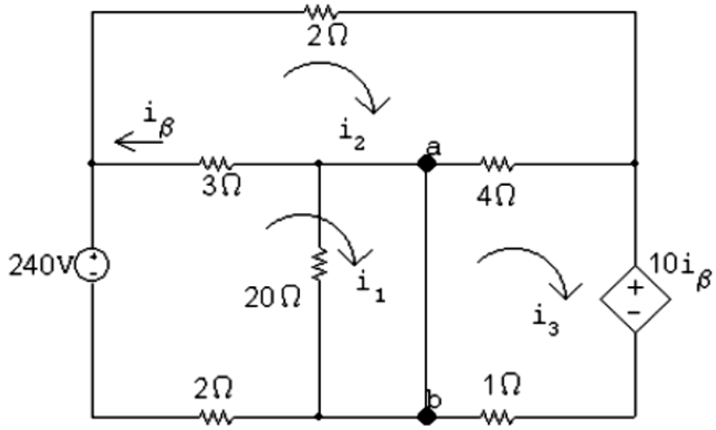
Place these equations in standard form:

$$
\begin{aligned}
i_1(3 + 20 + 2) + i_2(-3) + i_3(-20) + i_\beta(0) &= 240 \\
i_1(-3) + i_2(2 + 4 + 3) + i_3(-4) + i_\beta(0) &= 0 \\
i_1(-20) + i_2(-4) + i_3(1 + 20 + 4) + i_\beta(10) &= 0 \\
i_1(-1) + i_2(1) + i_3(0) + i_\beta(-1) &= 0
\end{aligned}
$$

Solving, $i_1 = 99.6$ A; $i_2 = 78$ A; $i_3 = 100.8$ A; $i_\beta = 21.6$ A

$V_{\text{Th}} = 20(i_1 - i_3) = -24$ V

Short-circuit current:



The mesh current equations are:

$$-240 + 3(i_1 - i_2) + 2i_1 = 0$$

$$2i_2 + 4(i_2 - i_3) + 3(i_2 - i_1) = 0$$

$$10i_\beta + 1i_3 + 4(i_3 - i_2) = 0$$

The dependent source constraint equation is:

$i_\beta = i_2 - i_1$

Place these equations in standard form:

$$i_1(3+2) + i_2(-3) + i_3(0) + i_\beta(0) = 240$$

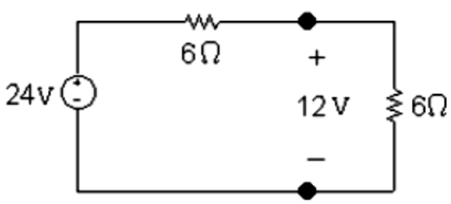
$$i_1(-3) + i_2(2+4+3) + i_3(-4) + i_\beta(0) = 0$$

$$i_1(0) + i_2(-4) + i_3(4+1) + i_\beta(10) = 0$$

$$i_1(-1) + i_2(1) + i_3(0) + i_\beta(-1) = 0$$

Solving, $i_1 = 92$ A; $i_2 = 73.33$ A; $i_3 = 96$ A; $i_\beta = 18.67$ A

$i_{sc} = i_1 - i_3 = -4$ A; $R_{Th} = \frac{V_{Th}}{i_{sc}} = \frac{-24}{-4} = 6\,\Omega$



$R_L = R_{Th} = 6\,\Omega$

[b] $p_{max} = \frac{12^2}{6} = 24$ W

[c] at P_L=24 Watt = P_{max} ➔ R_L=R_{TH}=6 ohms

<u>Question ❹</u> (***8 marks***) 10

The op amp in the circuit in Fig.4 is ideal. Using $V_{cc} = \pm 5V$,

a) Find the range of values for σ in which the op amp does not saturate.

b) Find i_o in microamperes when $\sigma = 0.272$

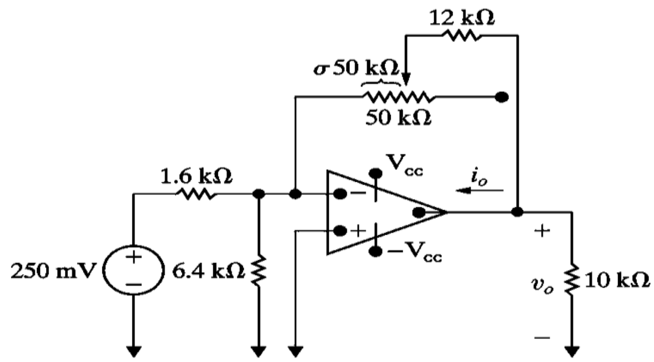
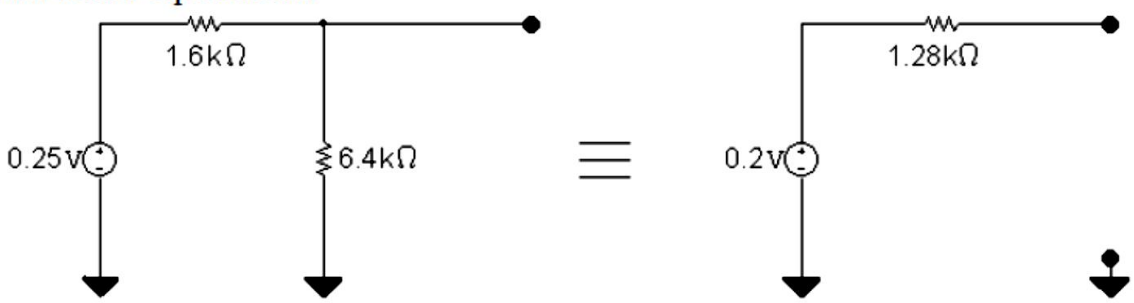


Fig.4

[a] Replace the combination of v_g, 1.6 kΩ, and the 6.4 kΩ resistors with its Thévenin equivalent.



Then $\quad v_o = \dfrac{-[12 + \sigma 50]}{1.28}(0.20)$

At saturation $\quad v_o = -5 \text{ V}; \qquad$ therefore

$$-\left(\frac{12 + \sigma 50}{1.28}\right)(0.2) = -5, \quad \text{or} \quad \sigma = 0.4$$

Thus for $0 \leq \sigma \leq 0.40$ the operational amplifier will not saturate.

[b] When $\quad \sigma = 0.272, \qquad v_o = \dfrac{-(12 + 13.6)}{1.28}(0.20) = -4 \text{ V}$

Also $\quad \dfrac{v_o}{10} + \dfrac{v_o}{25.6} + i_o = 0$

$$\therefore \quad i_o = -\frac{v_o}{10} - \frac{v_o}{25.6} = \frac{4}{10} + \frac{4}{25.6} \text{ mA} = 556.25\,\mu\text{A}$$

Good Luck