Benha University
Benha Faculty of Engineering
January, 2017
Exam (تخلفات)
Examiner: *Dr. Wael A. Mohamed*

Department: **Electrical Engineering**
Time: 3 Hours.
B. Sc. Course Exam
Subject: Elec. Eng. And Circuit Analysis (a)
E1101

Exam With Model Answer

Question ❶ (***15 marks***)

In the circuit in Fig.1(a) the device labeled D represents a component that has the equivalent circuit shown in Fig.1(b).The labels on the terminals of D show how the device is connected to the circuit. Find v_x and the power absorbed by the device.

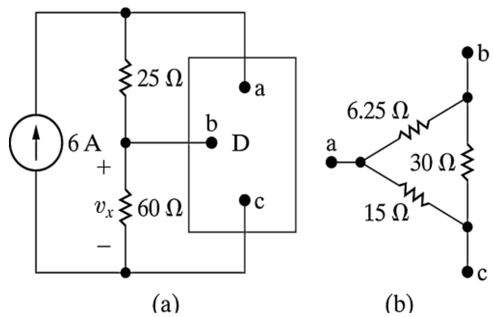
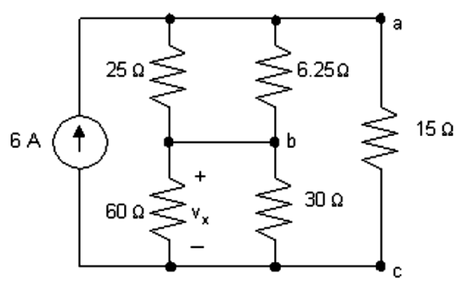
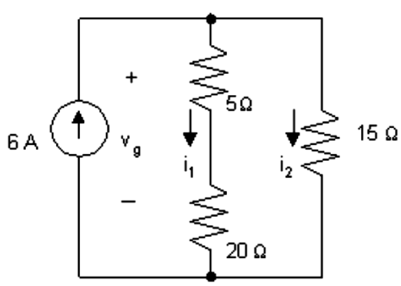


Fig.1



$25\|6.25 = 5\,\Omega \qquad 60\|30 = 20\,\Omega$



$$i_1 = \frac{(6)(15)}{(40)} = 2.25 \text{ A}; \qquad v_x = 20 i_1 = 45 \text{ V}$$

$$v_g = 25 i_1 = 56.25 \text{ V}$$

$$v_{6.25} = v_g - v_x = 11.25 \text{ V}$$

$$P_{\text{device}} = \frac{11.25^2}{6.25} + \frac{45^2}{30} + \frac{56.25^2}{15} = 298.6875 \text{ W}$$

Question **❷** (***15 marks***)

For the circuit shown in Fig.2,

a) Write the node voltage equations needed to find the voltages v_a and v_Δ. (***Write both the main equations and the auxiliary equations***).

b) Write the mesh current equations needed to find the voltages v_a and v_Δ. (***Write both the main equations and the auxiliary equations***).

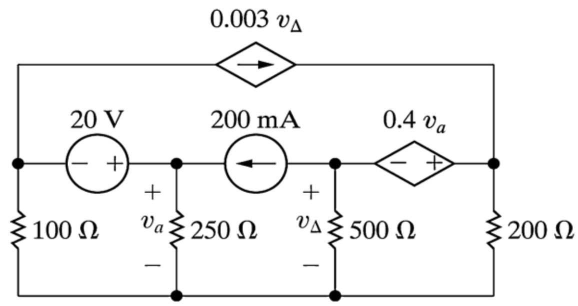
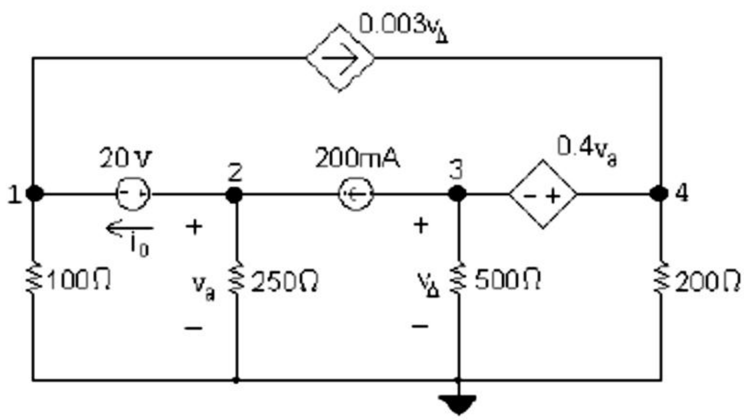


Fig.2

a)



Node voltage equations:

$$\frac{v_1}{100} + 0.003v_\Delta + \frac{v_2}{250} - 0.2 = 0$$

$$0.2 + \frac{v_3}{100} + \frac{v_4}{200} - 0.003v_\Delta = 0$$

b) Write the mesh equations by yourself.

Question ❸ (***15 marks***)

a) Find the Norton equivalent circuit with respect to the terminals a,b for the circuit seen in Fig.3.
b) Find the maximum power that could be transferred to the load connected across the terminals a,b.

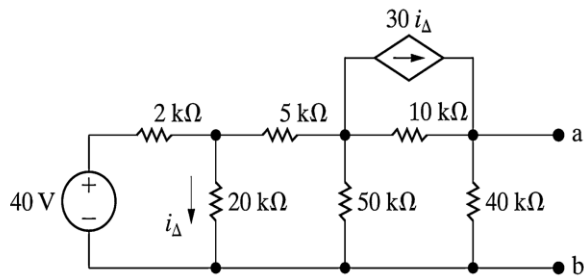
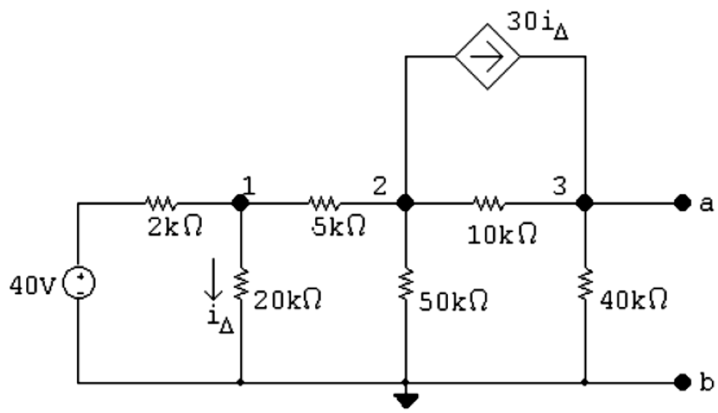


Fig.3

a) Norton equivalent circuit



The node voltage equations are:

$$\frac{v_1 - 40}{2000} + \frac{v_1}{20{,}000} + \frac{v_1 - v_2}{5000} = 0$$

$$\frac{v_2 - v_1}{5000} + \frac{v_2}{50{,}000} + \frac{v_2 - v_3}{10{,}000} + 30\frac{v_1}{20{,}000} = 0$$

$$\frac{v_3 - v_2}{10{,}000} + \frac{v_3}{40{,}000} - 30\frac{v_1}{20{,}000} = 0$$

In standard form:

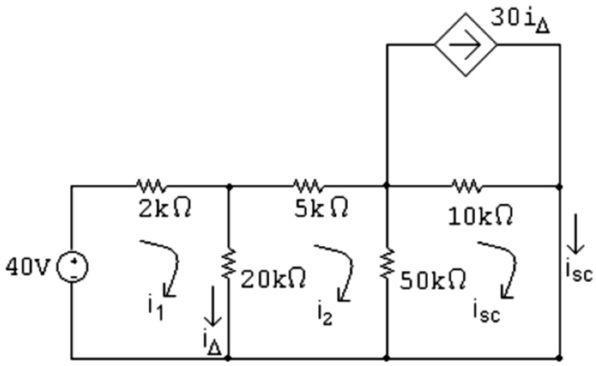
$$v_1\left(\frac{1}{2000} + \frac{1}{20{,}000} + \frac{1}{5000}\right) + v_2\left(-\frac{1}{5000}\right) + v_3(0) = \frac{40}{2000}$$

$$v_1\left(-\frac{1}{5000} + \frac{30}{20{,}000}\right) + v_2\left(\frac{1}{5000} + \frac{1}{50{,}000} + \frac{1}{10{,}000}\right) + v_3\left(-\frac{1}{10{,}000}\right) = 0$$

$$v_1\left(-\frac{30}{20{,}000}\right) + v_2\left(-\frac{1}{10{,}000}\right) + v_3\left(\frac{1}{10{,}000} + \frac{1}{40{,}000}\right) = 0$$

Solving, $v_1 = 24$ V; $v_2 = -10$ V; $v_3 = 280$ V

$V_{\text{Th}} = v_3 = 280$ V



The mesh current equations are:

$$-40 + 2000i_1 + 20{,}000(i_1 - i_2) = 0$$

$$5000i_2 + 50{,}000(i_2 - i_{\rm sc}) + 20{,}000(i_2 - i_1) = 0$$

$$50{,}000(i_{\rm sc} - i_2) + 10{,}000(i_{\rm sc} - 30i_\Delta) = 0$$

The constraint equation is:

$$i_\Delta = i_1 - i_2$$

Put these equations in standard form:

$$i_1(22{,}000) + i_2(-20{,}000) + i_{\rm sc}(0) + i_\Delta(0) = 40$$

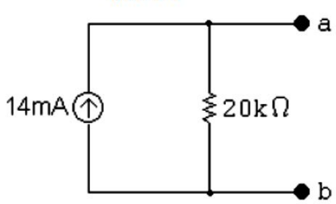
$$i_1(-20{,}000) + i_2(75{,}000) + i_{\rm sc}(-50{,}000) + i_\Delta(0) = 0$$

$$i_1(0) + i_2(-50{,}000) + i_{\rm sc}(60{,}000) + i_\Delta(-300{,}000) = 0$$

$$i_1(-1) + i_2(1) + i_{\rm sc}(0) + i_\Delta(1) = 0$$

Solving, $i_1 = 13.6$ mA; $i_2 = 12.96$ mA; $i_{\rm sc} = 14$ mA; $i_\Delta = 640\,\mu$A

$$R_{\rm Th} = \frac{280}{0.014} = 20\ {\rm k}\Omega$$



b) The maximum power transferred to the load = $(V_{th})^2/4R_{th}$ = 0.98 Watt

Question ❹ (***15 marks***)

The op amp in the circuit in Fig.4 is ideal. Using V_{cc} = ± ***10V***, Find the value of σ in which the op amp does not saturate.

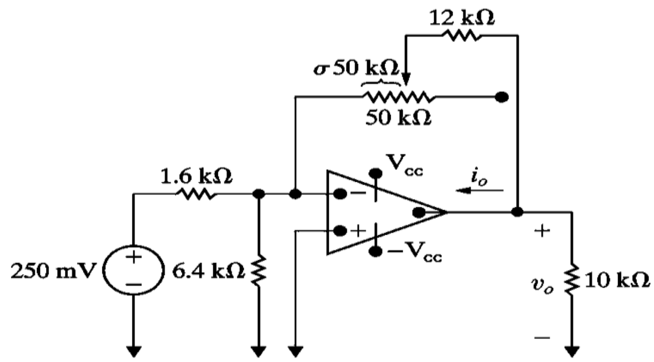
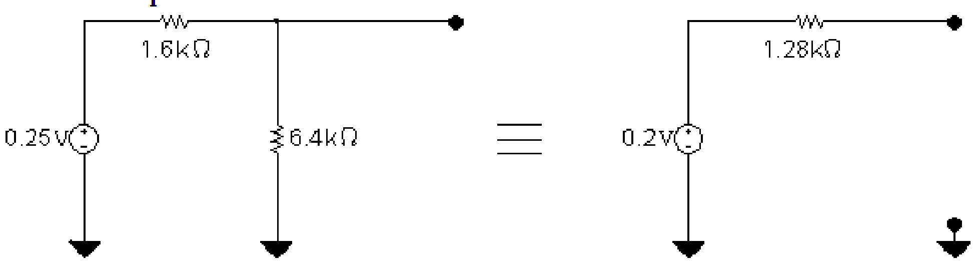


Fig.4

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



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

At saturation $v_o = -10\text{V}$; therefore

$$-\left(\frac{12+\sigma 50}{1.28}\right)(0.2) = -10 \quad \text{or} \quad \sigma = 1.04$$

The max value for σ is 1, so any value of σ will not saturate the amplifier.

Good Luck,