Final Written Examination.

Time all: 3 Hrs

30/12/2014

Answer the following questions

Question (1): **[12 Marks]**

a) Use Kirchhoffs laws and Ohm's law to find the voltage v_o as shown in Fig.1.

b) Show that your solution is consistent with the constraint that the total power developed in the circuit equals the total power dissipated.

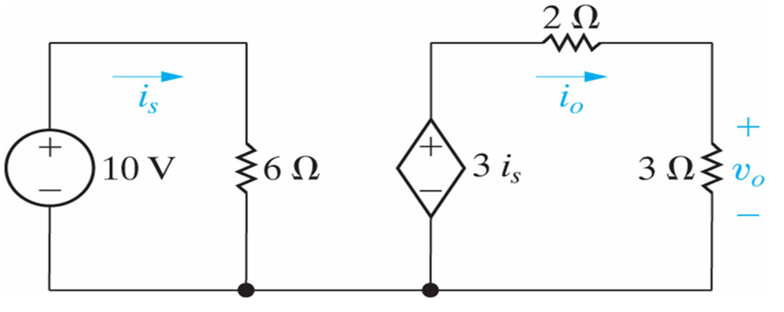

Fig.1

- Once i_o is known, we can compute v_o.

We need two equations for the two currents. Because there are two closed paths and both have voltage sources, we can apply Kirchhoff's voltage law to each to give the following equations:

$$10 = 6i_s,$$

$$3i_s = 2i_o + 3i_o.$$

Solving for the currents yields

$$i_s = 1.67 \text{ A},$$

$$i_o = 1 \text{ A}.$$

Applying Ohm's law to the 3 Ω resistor gives the desired voltage:

$$v_o = 3i_o = 3 \text{ V}.$$

b) To compute the power delivered to the voltage sources, we use the power equation in the form $p = vi$. The power delivered to the independent voltage source is

$$p = (10)(-1.67) = -16.7 \text{ W}.$$

The power delivered to the dependent voltage source is

$$p = (3i_s)(-i_o) = (5)(-1) = -5 \text{ W}.$$

Both sources are developing power, and the total developed power is 21.7 W.

To compute the power delivered to the resistors, we use the power equation in the form $p = i^2R$. The power delivered to the 6 Ω resistor is

$$p = (1.67)^2(6) = 16.7 \text{ W}.$$

The power delivered to the 2 Ω resistor is

$$p = (1)^2(2) = 2 \text{ W}.$$

The power delivered to the 3 Ω resistor is

$$p = (1)^2(3) = 3 \text{ W}.$$

The resistors all dissipate power, and the total power dissipated is 21.7 W, equal to the total power developed in the sources.

Question (2): **[12 Marks]**

Find the current and power supplied by the 40 V source in the circuit shown in Fig.2.

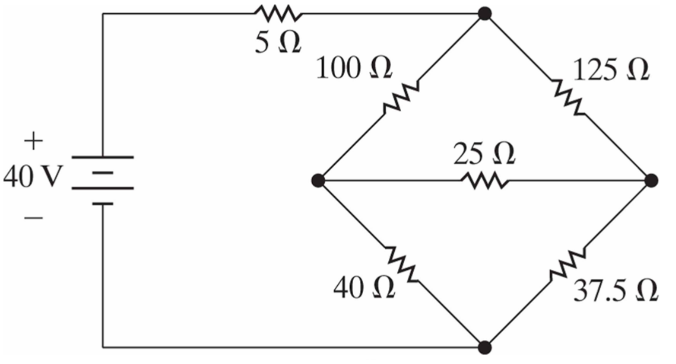

Fig.2

We are interested only in the current and power drain on the 40 V source, so the problem has been solved once we obtain the equivalent resistance across the terminals of the source. We can find this equivalent resistance easily after replacing either the upper Δ (100, 125, 25 Ω) or the lower Δ (40, 25, 37.5 Ω) with its equivalent Y. We choose to replace the upper Δ. We then compute the three Y

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resistances, defined in Fig. 3.33, from Eqs. 3.44 to 3.46. Thus,

$$R_1 = \frac{100 \times 125}{250} = 50\ \Omega,$$

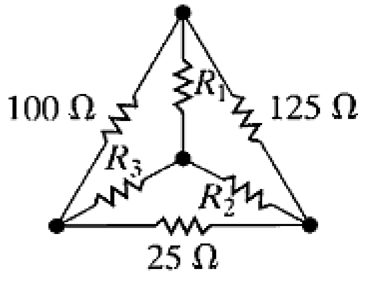
$$R_2 = \frac{125 \times 25}{250} = 12.5\ \Omega,$$

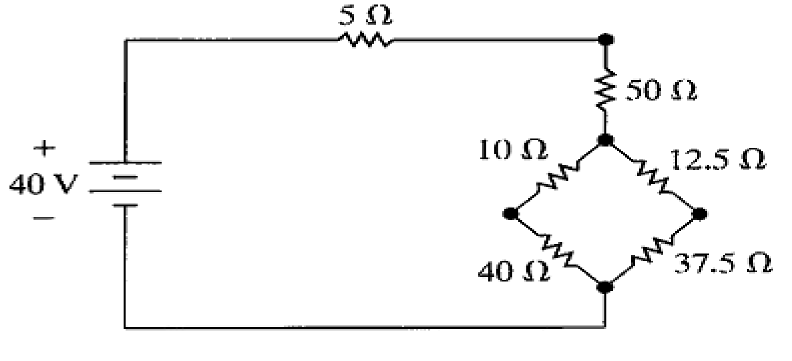
$$R_3 = \frac{100 \times 25}{250} = 10\ \Omega.$$

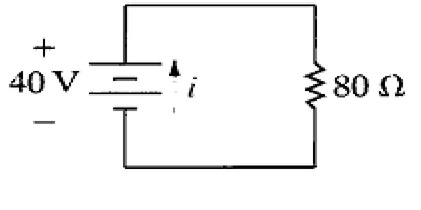
Substituting the Y-resistors into the circuit shown in Fig. 3.32 produces the circuit shown in Fig. 3.34. From Fig. 3.34, we can easily calculate the resistance across the terminals of the 40 V source by series-parallel simplifications:

$$R_{eq} = 55 + \frac{(50)(50)}{100} = 80\ \Omega.$$

The final step is to note that the circuit reduces to an 80 Ω resistor across a 40 V source, as shown in Fig. 3.35, from which it is apparent that the 40 V source delivers 0.5 A and 20 W to the circuit.







Question (3): **[12 Marks]**

Use the node-voltage method to find Vo in the circuit shown.

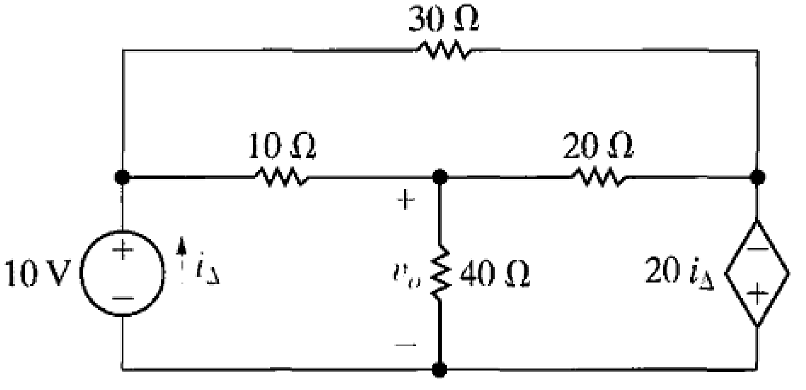


Fig.3

The node voltage equation is

$$\frac{v_o}{40} + \frac{v_o - 10}{10} + \frac{v_o + 20i_\Delta}{20} = 0$$

The constraint equation required by the dependent source is

$$i_\Delta = i_{10\Omega} + i_{30\Omega} = \frac{10 - v_o}{10} + \frac{10 + 20i_\Delta}{30}$$

Place these equations in standard form:

$$v_o\left(\frac{1}{40} + \frac{1}{10} + \frac{1}{20}\right) + i_\Delta(1) = 1$$

$$v_o\left(\frac{1}{10}\right) + i_\Delta\left(1 - \frac{20}{30}\right) = 1 + \frac{10}{30}$$

Solving, $i_\Delta = -3.2$ A and $v_o = 24$ V

Question (4): **[12 Marks]**

Find the Thevenin equivalent with respect to the terminals a,b for the circuit shown in Fig. 4.

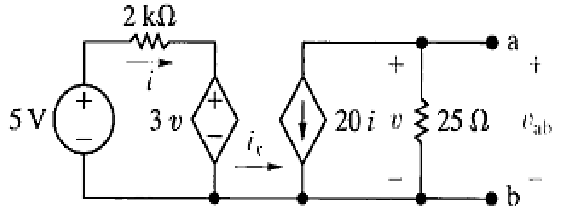


Fig.4

The first step in analyzing the circuit in Fig. 4.49 is to recognize that the current labeled i_x must be zero. (Note the absence of a return path for i_x to enter the left-hand portion of the circuit.) The open-circuit, or Thévenin, voltage will be the voltage across the 25 Ω resistor. With $i_x = 0$,

$$V_{Th} = v_{ab} = (-20i)(25) = -500i.$$

The current i is

$$i = \frac{5 - 3v}{2000} = \frac{5 - 3V_{Th}}{2000}.$$

In writing the equation for i, we recognize that the Thévenin voltage is identical to the control voltage. When we combine these two equations, we obtain

$$V_{Th} = -5 \text{ V}.$$

To calculate the short-circuit current, we place a short circuit across a,b. When the terminals a,b are shorted together, the control voltage v is reduced to zero. Therefore, with the short in place, the circuit shown in Fig. 4.49 becomes the one shown in Fig. 4.50. With the short circuit shunting the 25 Ω resistor, all the current from the dependent current source appears in the short, so

$$i_{sc} = -20i.$$

Good Luck ,,,,,,*Dr. Waleed Abdel Aziz Salem*

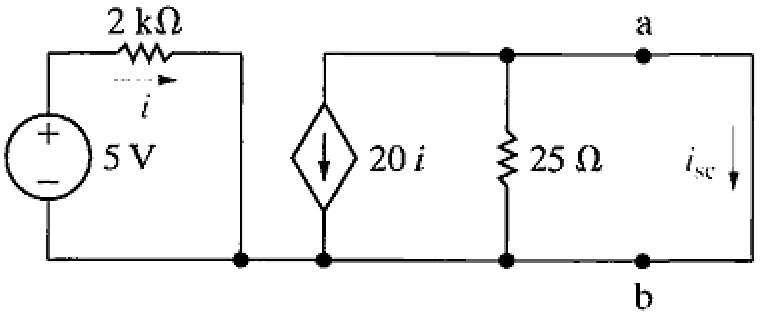


Figure 4.50 ▲ The circuit shown in Fig. 4.49 with terminals a and b short-circuited.

As the voltage controlling the dependent voltage source has been reduced to zero, the current controlling the dependent current source is

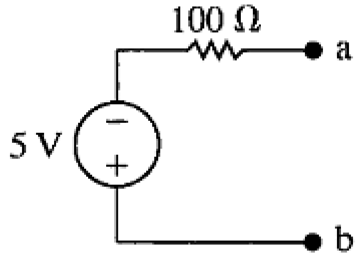
$$i = \frac{5}{2000} = 2.5 \text{ mA}.$$

Combining these two equations yields a short-circuit current of

$$i_{sc} = -20(2.5) = -50 \text{ mA}.$$

From i_{sc} and V_{Th} we get

$$R_{Th} = \frac{V_{Th}}{i_{sc}} = \frac{-5}{-50} \times 10^3 = 100\ \Omega.$$



Question (5): [12 Marks]

Use the concept of source transformation to find the phasor voltage Vo in the circuit shown in Fig. 5.

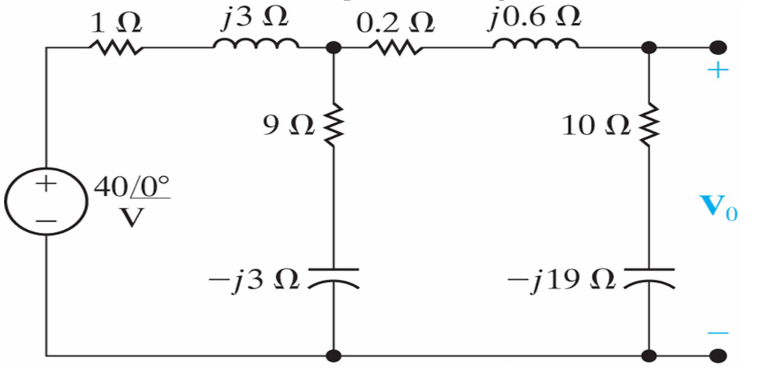


Fig. 5

We can replace the series combination of the voltage source ($40\angle 0^\circ$) and the impedance of $1 + j3\ \Omega$ with the parallel combination of a

current source and the $1 + j3\ \Omega$ impedance. The source current is

$$\mathbf{I} = \frac{40}{1 + j3} = \frac{40}{10}(1 - j3) = 4 - j12 \text{ A}.$$

Thus we can modify the circuit shown in Fig. 9.27 to the one shown in Fig. 9.28. Note that the polarity reference of the 40 V source determines the reference direction for **I**.

Next, we combine the two parallel branches into a single impedance,

$$Z = \frac{(1 + j3)(9 - j3)}{10} = 1.8 + j2.4\ \Omega,$$

which is in parallel with the current source of $4 - j12$ A. Another source transformation converts this parallel combination to a series combination consisting of a voltage source in series with the impedance of $1.8 + j2.4\ \Omega$. The voltage of the voltage source is

$$\mathbf{V} = (4 - j12)(1.8 + j2.4) = 36 - j12 \text{ V}.$$

Using this source transformation, we redraw the circuit as Fig. 9.29. Note the polarity of the voltage source. We added the current $\mathbf{I}_0$ to the circuit to expedite the solution for $\mathbf{V}_0$.

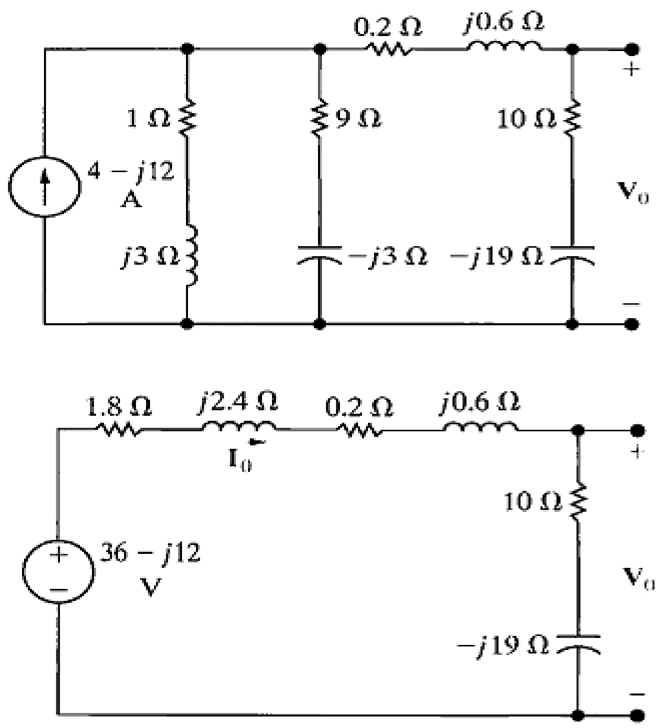


Figure 9.29 ▲ The second step in reducing the circuit shown in Fig. 9.27.

Also note that we have reduced the circuit to a simple series circuit. We calculate the current $\mathbf{I}_0$ by dividing the voltage of the source by the total series impedance:

$$\mathbf{I}_0 = \frac{36 - j12}{12 - j16} = \frac{12(3 - j1)}{4(3 - j4)}$$

$$= \frac{39 + j27}{25} = 1.56 + j1.08 \text{ A}.$$

We now obtain the value of $\mathbf{V}_0$ by multiplying $\mathbf{I}_0$ by the impedance $10 - j19$:

$$\mathbf{V}_0 = (1.56 + j1.08)(10 - j19) = 36.12 - j18.84 \text{ V}.$$

Good Luck ,,,,,,*Dr. Waleed Abdel Aziz Salem*