Eastern Mediterranean University
"For Your International Career"
Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EENG223 – Circuit Theory I

Midterm Exam
Spring 2014-15

29 April 2015
Duration: 100 minutes

Instructor: M. K. Uyguroğlu

STUDENT'S	
NUMBER	
NAME	
SURNAME	
GROUP NO.	

Problem		**Points**
1		20
2		40
3		20
4		20
TOTAL		100

Problem 1

Find i and R_{eq} if $v_{ab} = 40$ V in the circuit of Fig. P1

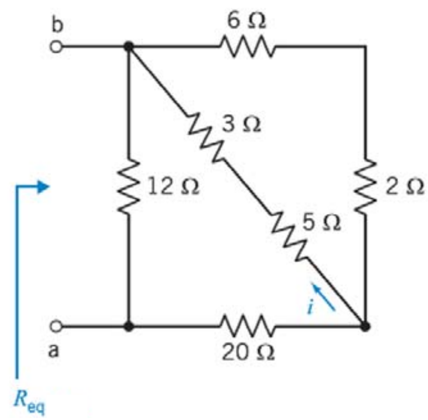


Figure P1

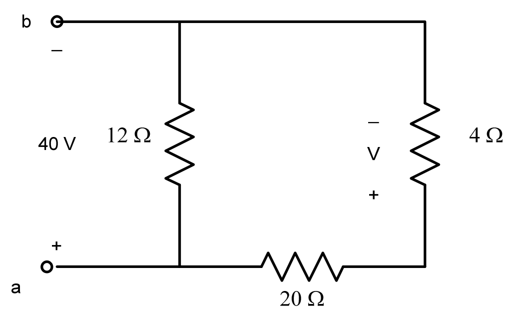
$$R_{eq} = \underbrace{12//\underbrace{(20+\underbrace{\underbrace{(3+5)}_{8}//\underbrace{(6+2)}_{8}}_{4})}_{24}}_{8} = 8\Omega$$

Using voltage division principle

$$v = 40\frac{4}{24} = \frac{40}{6}\text{V}$$

Therefore

$$i = \frac{v}{8} = \frac{40}{48} = \frac{5}{6}\ \text{A}$$



Problem 2

Find the voltage v_a in the circuit of Fig.P2 by using

(a) Nodal analysis
(b) Mesh analysis
(c) Source transformation
(d) Superposition
(e) Thevenin's and Norton's theorem.

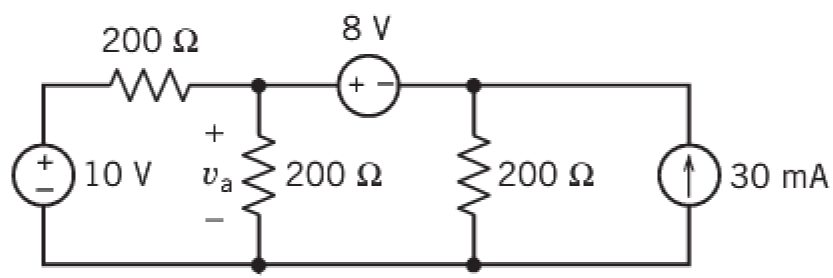
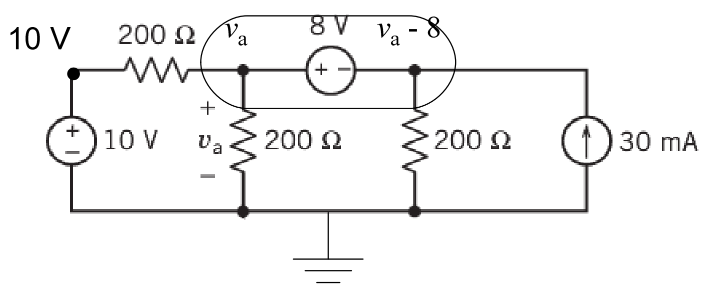


Figure P2

Nodal analysis



KCL at SUPERNODE:

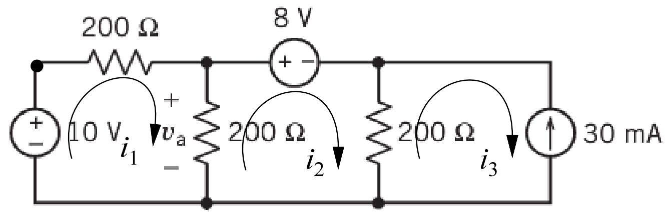
$$\left(\frac{1}{200}+\frac{1}{200}\right)v_a+\frac{1}{200}(v_a-8)-\frac{1}{200}10=30m$$

Multiply both sides by 200 yields:

$$3v_a=6+8+10=24$$

$$\boxed{v_a=8\text{ V}}$$

Mesh Analysis



$v_a = 200(i_1 - i_2)$

$i_3 = -30m\text{A}$

KVL around i_1

$400i_1 - 200i_2 = 10$.......(1)

KVL around i_2

$-200i_1 + 400i_2 - 200(-30m) = -8$

$-200i_1 + 400i_2 = -14$.......(2)

Multiply Eq.(2) by 2 and sum up Eqs.(1) and (2) gives:

$600i_2 = -18$

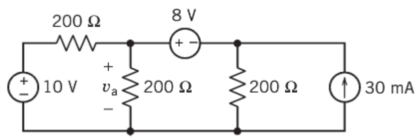
$$i_2 = -\frac{18}{600} = -0.03 \text{ A}$$

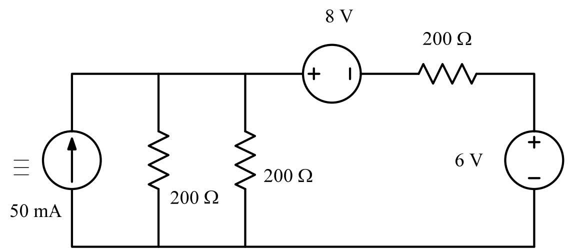
Therefore

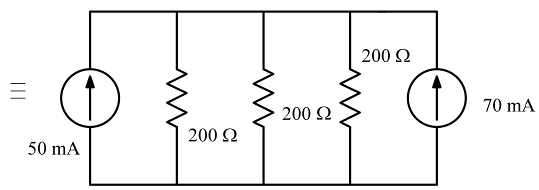
$$i_1 = \frac{400i_2 + 14}{200} = \frac{-12+14}{200} = \frac{2}{200} = 0.01 \text{ A}$$

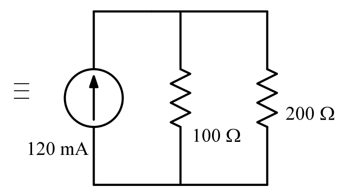
$v_a = 200(0.01 + 0.03) = 8 \text{ V}$

SOURCE TRANSFORMATION

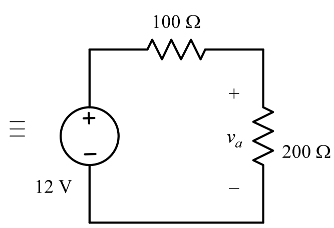








NORTON EQUIVALENT CIRCUIT

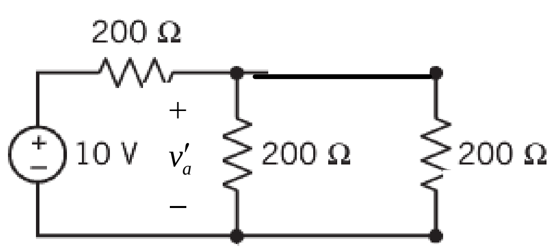


THEVENIN EQUIVALENT CIRCUIT

$$v_a = 12\frac{200}{300} = 8 \text{ V}$$

SUPERPOSITION

10 V Voltage source is active

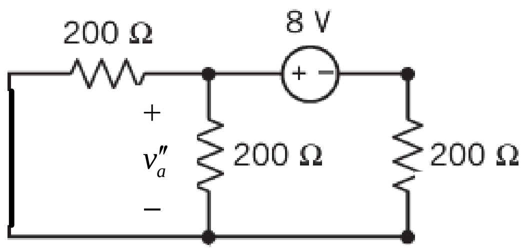


$$200\Omega // 200\Omega = 100\Omega$$

Then using voltage division principle

$$v'_a = 10\frac{100}{300} = \frac{10}{3} \text{ V}$$

8 V voltage source is active

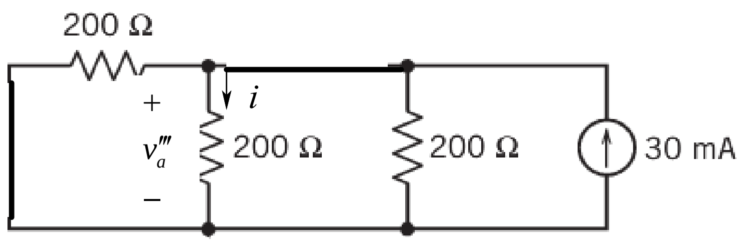


$200\Omega//200\Omega = 100\Omega$

Then using voltage division principle

$$v_a'' = 8\frac{100}{300} = \frac{8}{3}\ \text{V}$$

30 mA current source is active



Since all the resistors are in parallel and having the same resistance value**:**

$$i = \frac{30m}{3} = 10m\text{A}$$

$$v_a''' = 200 \times 10m = 2\ \text{V}$$

Therefore

$$v_a = v_a' + v_a'' + v_a''' = 8\ \text{V}$$

Problem 3

Find v in the circuit of Fig.P3.

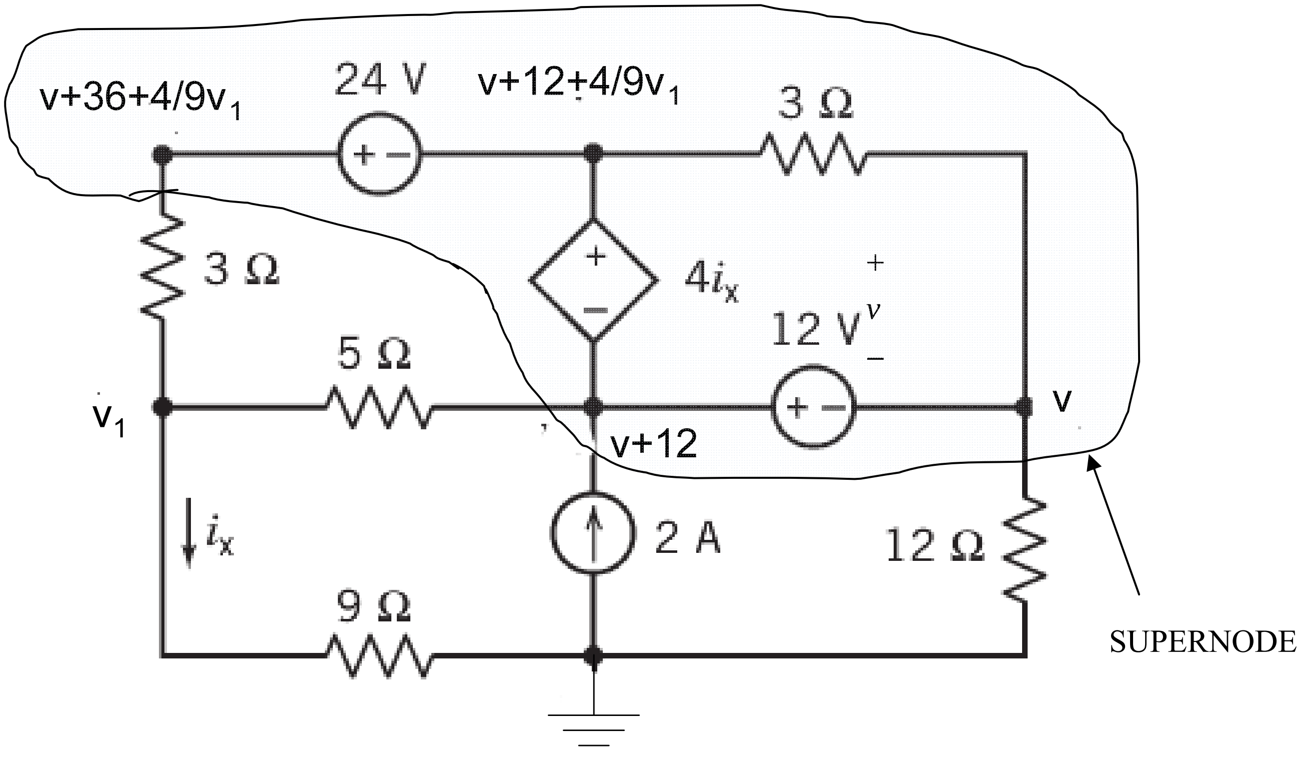


Figure P3

KCL at v_1 ;

$$\left(\frac{1}{3}+\frac{1}{5}+\frac{1}{9}\right)v_1-\frac{1}{3}\left(v+36+\frac{4}{9}v_1\right)-\frac{1}{5}(v+12)=0$$

KCL at SUPERNODE

$$-\left(\frac{1}{3}+\frac{1}{5}\right)v_1+\frac{1}{3}\left(v+36+\frac{4}{9}v_1\right)+\frac{1}{5}(v+12)+\frac{1}{12}v=2$$

$$-\frac{8}{15}v+\frac{67}{135}v_1=\frac{72}{5}$$

$$\frac{37}{60}v-\frac{52}{135}v_1=-\frac{62}{5}$$

$$\boxed{v=-6.037\text{ V}}$$

Problem 4

The variable resistor *R* in the circuit of Fig.P4 is adjusted until it absorbs the maximum power from the circuit.

(a) Calculate the value of *R* for maximum power

(b) Determine the maximum power absorbed by *R*.

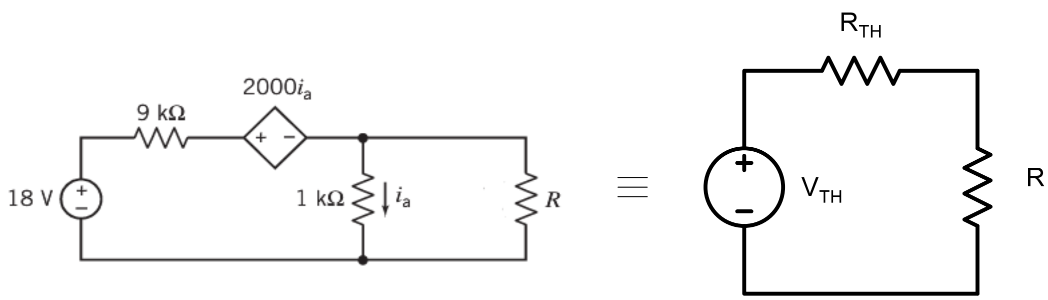
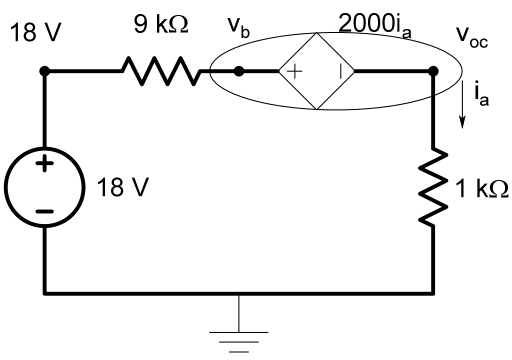


Figure P4

In order to find V_{TH} and R_{TH}, we will find open circuit voltage and short circuit current between the terminals where R is connected.



Where

$$v_b = v_{oc} + 2000 i_a$$

$$i_a = \frac{v_{oc}}{1k}$$

$$v_b = v_{oc} + 2v_{oc} = 3v_{oc}$$

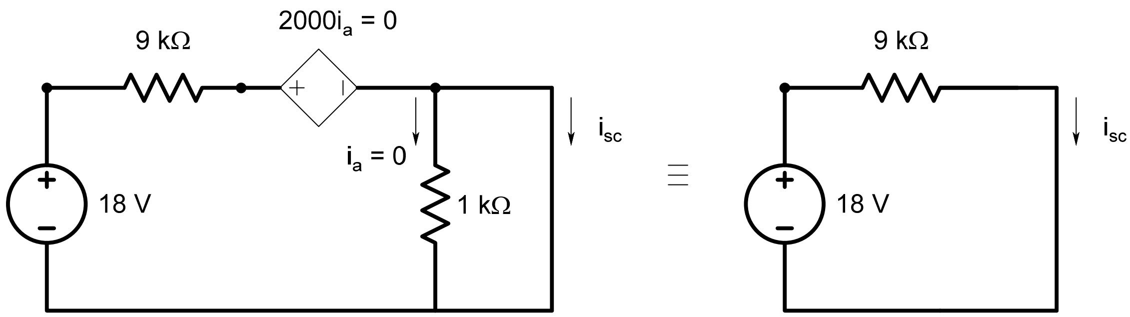
KCL at SUPERNODE:

$$\frac{1}{9k}3v_{oc} + \frac{1}{1k}v_{oc} - \frac{1}{9k}18 = 0$$

Multiply both sides by 9k yields:

$$12v_{oc} = 18$$

$$v_{oc} = 1.5 \text{ V}$$



$$i_{sc} = \frac{18}{9k} = 2m\text{A}$$

$$\text{R}_{TH} = \frac{1.5}{2m} = 0.75k\Omega$$

Therefore when $R = R_{TH}$ it will absorb maximum power and the maximum power is:

$$p_{\max} = \frac{V^2{}_{TH}}{4R_{TH}} = \frac{\frac{9}{4}}{4 \times \frac{3}{4}k} = \frac{9}{12}mW$$