CONCEPTUAL TOOLS

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Ref: Nilsson & Riedel, Rev 6, Prob 4.2

CIRCUITS
NODE-VOLTAGE METHOD
Example 1

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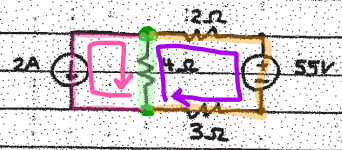
ex:



Use Node-Voltage method to find how much power the 2A source extracts from circuit.

First we use terminology:

nodes = 4 (two or more circuit elements join)

essential nodes = 2 (three or more circuit elements join; they are nodes for 4Ω resistor, top & bottom)

paths: 2A → 4Ω, 4Ω → 2Ω → 55V → 3Ω, 2Ω → 55V, 2A → 2Ω → 55V are a few examples (trace of connected circuit elements without passing thru any element twice)

branch: (path that connect 2 nodes) 2A, 4Ω, 2Ω, 3Ω, 2Ω → 55V, 55V → 3Ω, 3Ω → 55V (either direction OK), 55V, 2Ω → 55V → 3Ω

essential branch: (path connecting essential node w/o passing thru essential node) 2A, 4Ω, 2Ω → 55V → 3Ω, or 3Ω → 55V → 2Ω

loops: (path with last node = start node) 2A → 4Ω, 2A → 2Ω → 55V → 3Ω, 4Ω → 2Ω → 55V → 3Ω

mesh: (loop not enclosing any other loop) 2A → 4Ω, 4Ω → 2Ω → 55V → 3Ω but not 2A → 2Ω → 55V → 3Ω

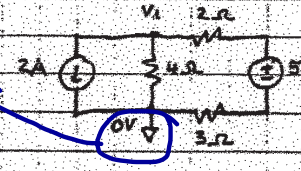
planar circuit: (can draw circuit w/o crossover branches) it planar

For Node-V method, we use all but 1 essential nodes after we define a ref node.

Choose node at bottom of 4Ω as ref node (i.e. 0V.)

↓ symbol ≡ 0V

most branches joining



Node at top of 4Ω is the other essential node. Label it V_1

Although we call it the Node-V method, (because we get an equation that we solve for voltage), we are writing an equation for sum of currents out of node = 0.

$$2A + \frac{V_1 - 0V}{4\Omega} + \frac{V_1 - 55V}{2\Omega + 3\Omega} = 0A$$

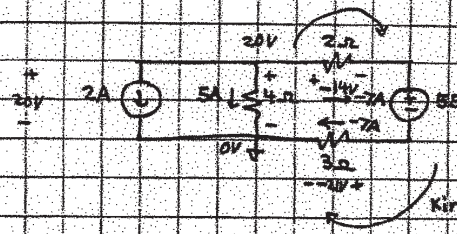
Note that current thru 2Ω is equal to total V-drop (i.e. $V_1 - 55V$) across the 2Ω and 3Ω R's.

$$\text{or } V_1\left(\frac{1}{4\Omega} + \frac{1}{5\Omega}\right) = -2A + \frac{55V}{5\Omega}$$

$$\text{or } \frac{V_1}{4\Omega \| 5\Omega} = 11A - 2A = 9A$$

$$\text{or } V_1 = 9A \cdot 4\Omega \| 5\Omega = 9A \cdot \frac{4\Omega \cdot 5\Omega}{4\Omega + 5\Omega} = 20\,V$$

check: $\frac{V_1}{4\Omega} = \frac{20V}{4\Omega} = 5A$ $\quad \frac{V_1 - 55V}{2\Omega + 3\Omega} = \frac{-35V}{5\Omega} = -7A$



$-55V - -21V + 20V - -14V$
$= -55V + (21 + 20 + 14)\,V$
$= 0V$ ✓

Kirchoff V Loop

check: current out of top node for 4Ω is $2A + 5A - 7A = 0$ ✓

Calculate power for 2A source: $p = i \cdot v = 2A \cdot 2V = 40W$

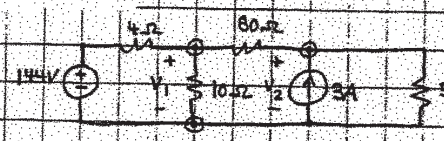
$p > 0 \Rightarrow$ power absorbed.

By: Neil E. Cotter

Ref: Nilsson & Riedel, Rev 6, Prob 4.9

CIRCUITS
NODE-VOLTAGE METHOD
Example 2

ex:

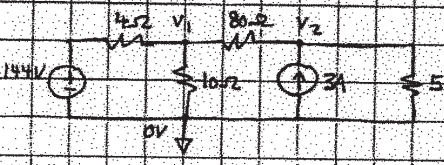


Use Node-V method to find V_1 & V_2.

Soln: nodes are marked by dots. Essential nodes are marked by ⊙. Note that node under 3A source is considered to be part of essential node under 10Ω Resistor, (because they are connected by a wire).

3 essential nodes ⇒ 3 − 1 = 2 equations needed.

Put ref V of 0V, (i.e. ⏚), at bottom so top nodes are V_1 and V_2.



Node-V eqn's give sum of currents out of node = 0.

node 1 (V_1): $\frac{V_1 - 144V}{4\Omega} + \frac{V_1 - 0V}{10\Omega} + \frac{V_1 - V_2}{80\Omega} = 0A$

node 2 (V_2): $\frac{V_2 - V_1}{80\Omega} + -3A + \frac{V_2 - 0V}{5\Omega} = 0A$

or

node 1: $V_1\left(\frac{1}{4\Omega} + \frac{1}{10\Omega} + \frac{1}{80\Omega}\right) - \frac{V_2}{80\Omega} = \frac{144V}{4\Omega}$

node 2: $-V_1\frac{1}{80\Omega} + V_2\left(\frac{1}{80\Omega} + \frac{1}{5\Omega}\right) = 3A$

or

node 1: $\frac{V_1}{4\Omega \| 10\Omega \| 80\Omega} - \frac{V_2}{80\Omega} = \frac{144V}{4\Omega}$

node 2: $-\frac{V_1}{80\Omega} + \frac{V_2}{80\Omega \| 5\Omega} = 3A$

$4\Omega \| 10\Omega \| 80\Omega = (4\Omega \| 16\Omega) \| 80\Omega$

$= \frac{40}{14}\Omega \| 80\Omega$

$= 40\Omega \cdot \frac{1}{14} \| 2$

$= 40\Omega \cdot \frac{2/14}{2 + 1/14}$

$= 40\Omega \cdot \frac{2}{29}$ (mult. top & bottom by 14)

$= \frac{80}{29}\Omega$

$80\Omega \| 5\Omega = 5\Omega \cdot 16\| 1 = 5\Omega \cdot \frac{16}{17} = \frac{80}{17}\Omega$

Thus, we have: node 1 $V_1 \frac{29}{80\Omega} - \frac{V_2}{80\Omega} = 36\,A$

node 2 $-\frac{V_1}{80\Omega} + V_2 \frac{17}{80\Omega} = 3\,A$

or node 1 $29V_1 - V_2 = 2880\,V$

node 2 $-V_1 + 17V_2 = 240\,V$

From node 1: $-V_2 = 2880V - 29V_1$; substitute this into Node 2:

node 2: $-V_1 - 17(2880V - 29V_1) = 240\,V$

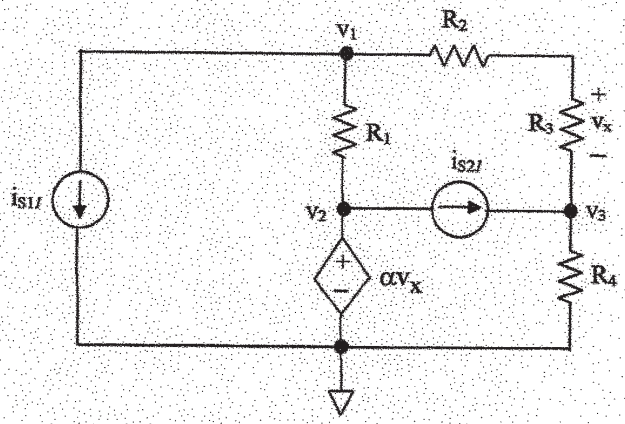
$492V_1 = 240V + 48960$

$V_1 = 100\,V$

$V_2 = \frac{240V + V_1}{17} = \frac{340\,V}{17} = 20\,V$

Node Voltage Example

1. a.

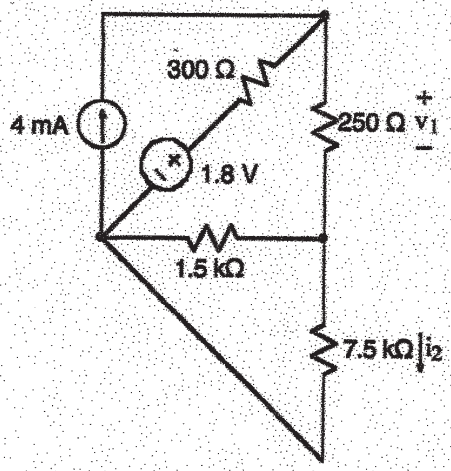


For the circuit shown, write three independent equations for the node voltages v_1, v_2, and v_3. The quantity v_x must not appear in the equations.

b. Make a consistency check on your equations for problem 1 by setting resistors and sources to values for which the values of v_1, v_2, and v_3 are obvious. State the values of resistors, sources, and v_1, v_2, v_3 for your consistency check, and show that your equations for problem 1(a) are satisfied for these values. (In other words, plug the values into your equations for problem 1(a).)

Node Voltage Example

Ex:



a) Use the node-voltage method to calculate v_1 and i_2.

b) Calculate the power in the 300 Ω resistor.