Circuits Analysis with Dependent Sources

Lec-09

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Objective of Lecture

- Describe how dependent voltage and current sources function.
- Explain how they are treated when analyzing a circuit and provide examples.

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Summary

- Dependent sources are voltage or current sources whose output is a function of another parameter in the circuit.
  - Voltage controlled voltage source (VCVS)
  - Current controlled current source (CCCS)
  - Voltage controlled current source (VCCS)
  - Current controlled voltage source (CCVS)
- Dependent sources only produce a voltage or current when an independent voltage or current source is in the circuit.
- Dependent sources are treated like independent sources when using nodal or mesh analysis, but **not** with superposition/Thevenin's and Norton's Theorems.

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Dependent Sources

- The output voltage or current of a dependent source is determined by one of the parameters associated with another component in the circuit.
  - In this course, the parameter is the voltage across or current flowing through the other component.
  - Other parameters may be the component's resistance, amount of light shining on the component, the ambient temperature, and mechanical stress applied to the component including changes in atmospheric pressure.

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Circuit Analysis

- Treat similar to the independent voltage and current sources when performing nodal and mesh analysis.
- Do not treat like an independent source when using superposition.
  - Independent voltage and current sources are turned on and off as we apply superposition. Dependent sources remain on.

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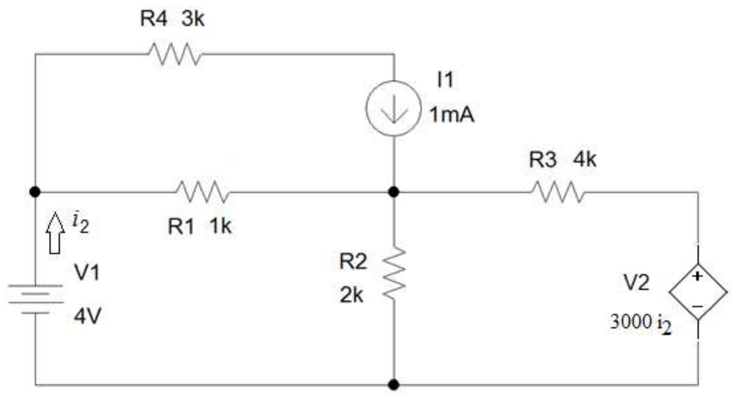
Superposition with dependent sources



V2 is a current controlled voltage source (CCVS).

The value of the voltage of the CCVS is 3000 times the current i_2, which is the current flowing out of V1.

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Example (con't)

- The two circuits that will be analyzed are

1. When V1 is on and I1 is turned off.

2. When I1 is on and V1 is turned off.
   - In both circuits, V2 is left on.

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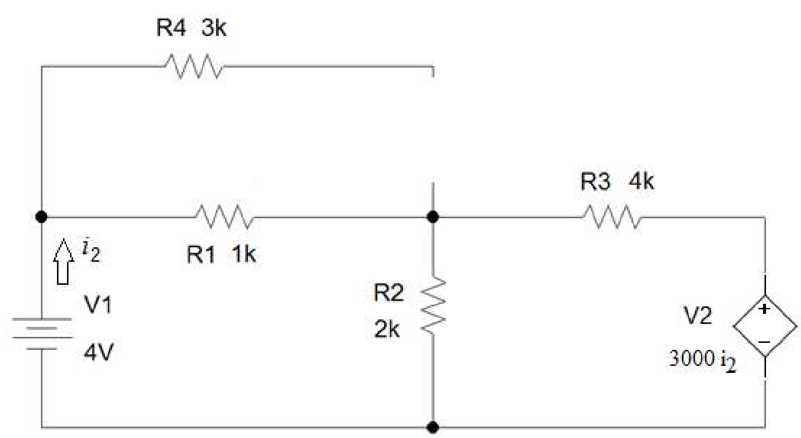
Example(con't)

1. When V1 is on and I1 is turned off.



When I1 is turned off, one terminal of R4 is not connected to the rest of the circuit an it can be eliminated.

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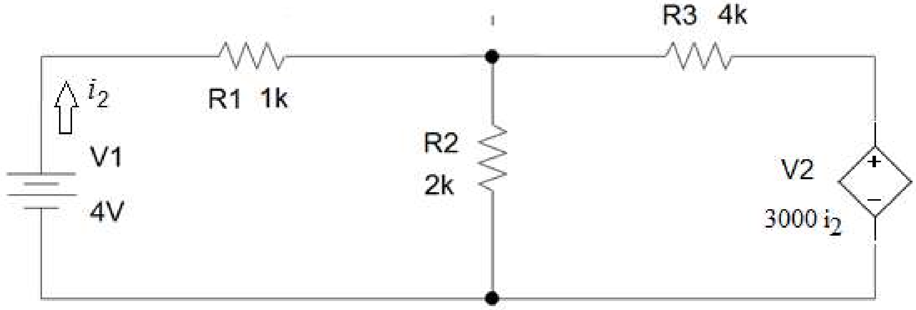
Example (con't)



You can select any analysis to solve for i_2 .

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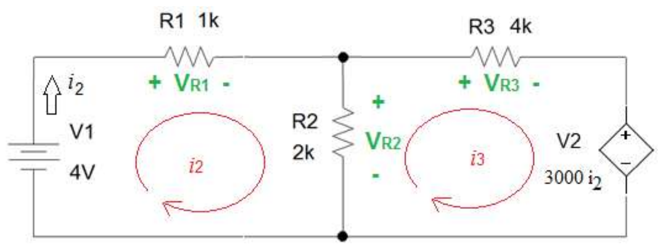
Example (con't)



$$V_1 - V_{R1} - V_{R2} = 0$$
$$-V_{R2} - V_{R3} - V_2 = 0$$

$$V_1 = 4V$$
$$V_{R1} = i_2 R_1$$
$$V_{R2} = (i_2 - i_3) R_2$$
$$V_{R3} = i_3 R_3$$
$$V_2 = 3000 i_2$$

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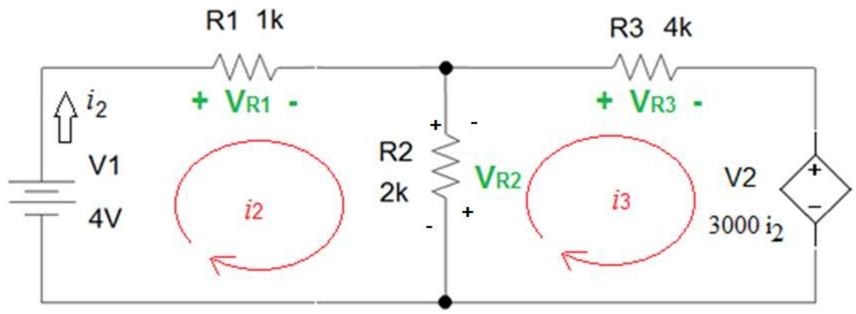
Example (con’t)



$$4V - i_2(1k\Omega) - (i_2 - i_3)(2k\Omega) = 0$$
$$-(i_3 - i_2)(2k\Omega) - i_3(4k\Omega) - 3000\, i_2 = 0$$

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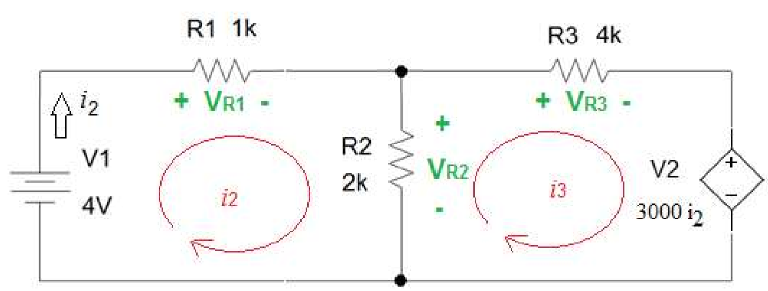
Example (con’t)



Currents		Dependent Source	
i2	1.2mA	V2	3.60V
i3	-0.2mA		

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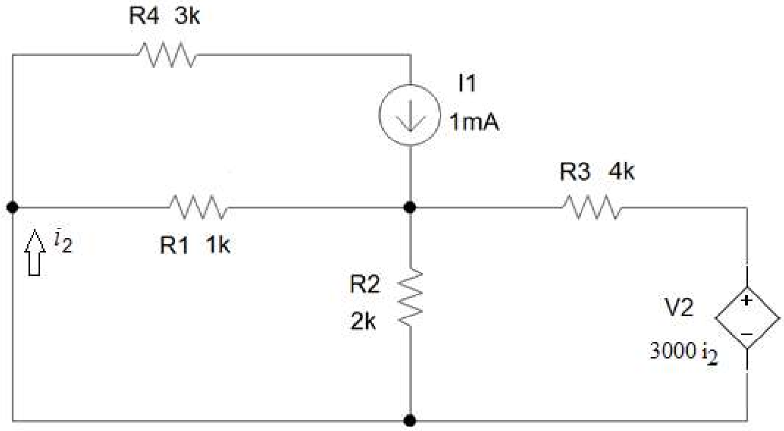
Now Consider Effect of independent current source keeping independent voltage source to zero

i.e. When I1 is on and V1 is turned off.



Again, you can select which ever analysis technique that you would like in order to solve for i_2.

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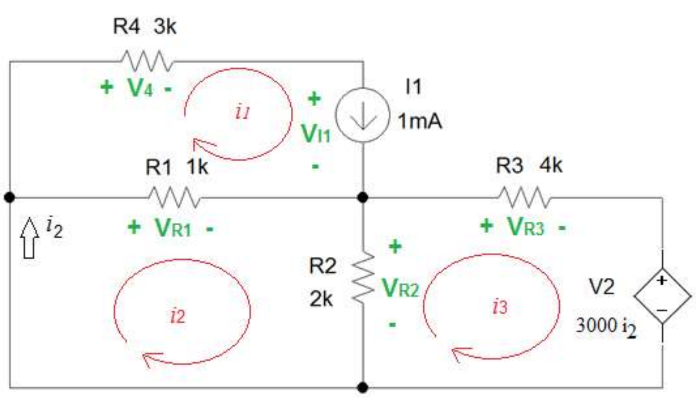

$$V_{R1}+V_{R2}=0$$
$$-V_{R2}+V_{R3}+V_2=0$$
$$V_4+V_{I1}-V_{R1}=0$$

$$I_1=i_1=1mA$$
$$V_{R1}=(i_2-i_1)R_1$$
$$V_{R2}=(i_2-i_3)R_2$$
$$V_{R3}=i_3R_3$$
$$V_{R4}=i_1R_4$$
$$V_2=3000i_2$$

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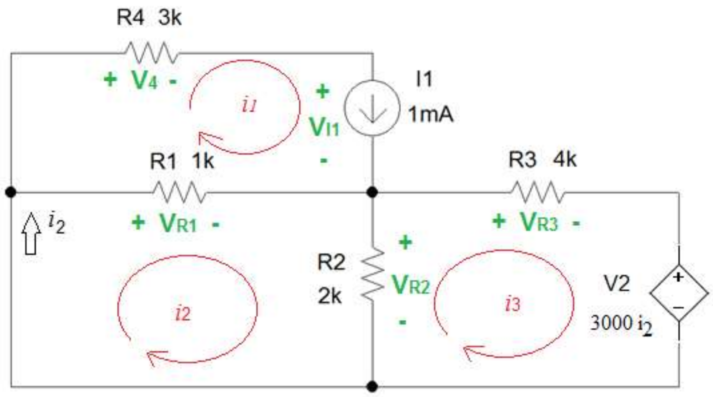

$$(i_2 - 1mA)(1k\Omega) + (i_2 - i_3)(2k\Omega) = 0$$
$$-(i_2 - i_3)(2k\Omega) + i_3 R_3 + 3000\, i_2 = 0$$
$$i_1(3k\Omega) + V_{I1} - (i_2 - 1mA)(1k\Omega) = 0$$

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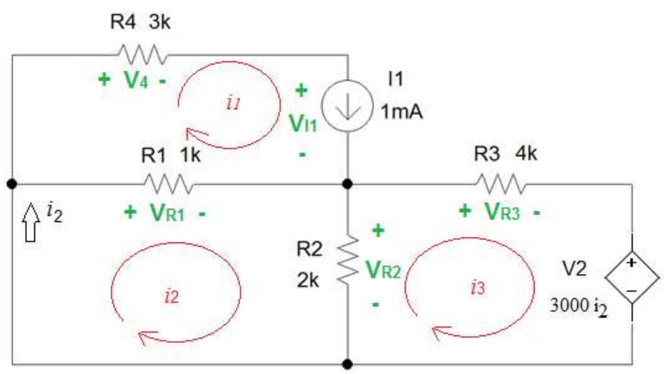
Example #2 (con't)



Currents		Dependent Source	
i2	0.3mA	V2	0.9V
i3	-50µA		

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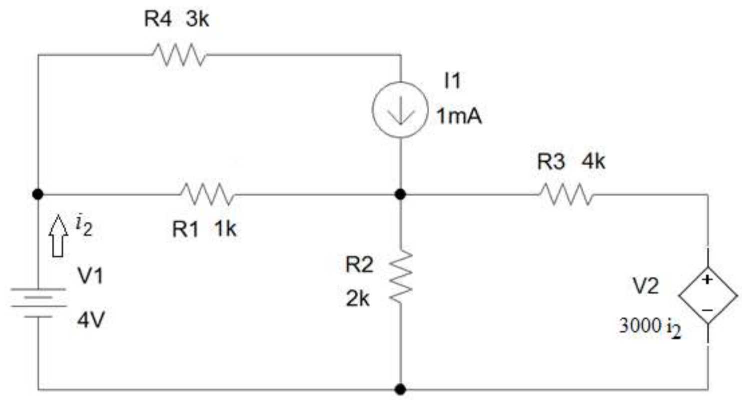
Example (con’t)



Final Value of dependent voltage source using superposition theorem:

Currents		Dependent Source	
i2	(1.2+0.3)mA=1.5mA	V2	(3.6+0.9)V=4.5V

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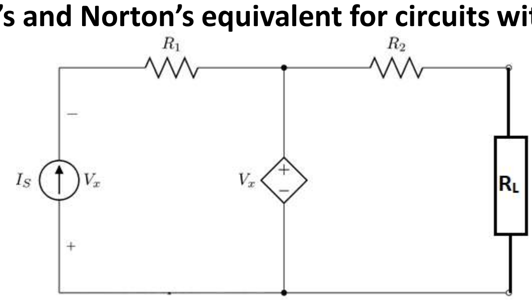
Thevenin’s and Norton’s equivalent for circuits with dependent sources

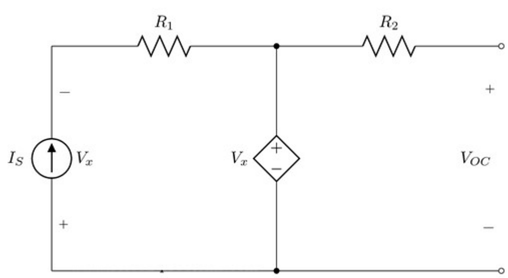


$R_{TH}= R_N= V_{OC} / I_{SC}$

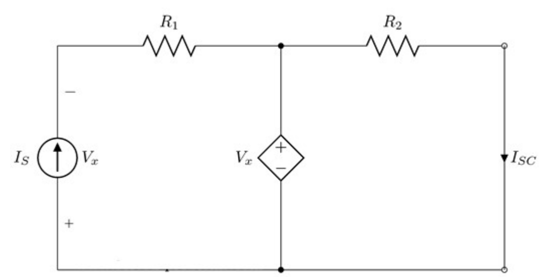
$V_{TH} = V_{OC}$

$I_N= I_{SC}$

Circuit for Open Ckt (Thevenin’s) Voltage for given R_L



Circuit for Short ckt (Norton’s) Current for given R_L



$R_{TH}= R_N= V_{OC} / I_{SC}$

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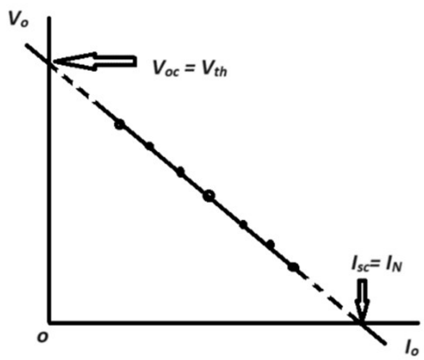
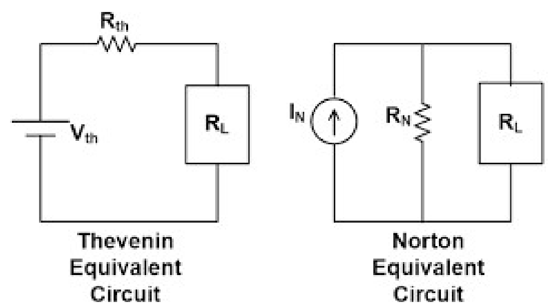
- $R_{TH} = R_N = V_{OC} / I_{SC}$
- $V_{TH} = V_{OC}$
- $I_N = I_{SC}$





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Practice Session

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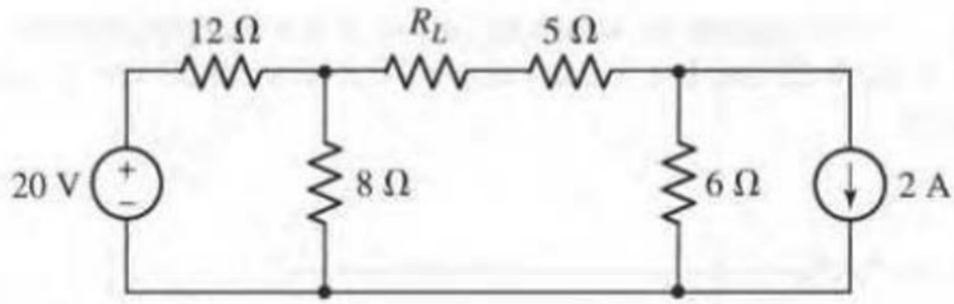
. If any value whatsoever may be selected for R_L in the circuit of Fig. 5.101, what is the maximum power that could be dissipated in R_L?



■ **FIGURE 5.101**

Ans: For Max. Power R_L=R_{th}= 15.8 Ohm, and Pmax= 6.329 W

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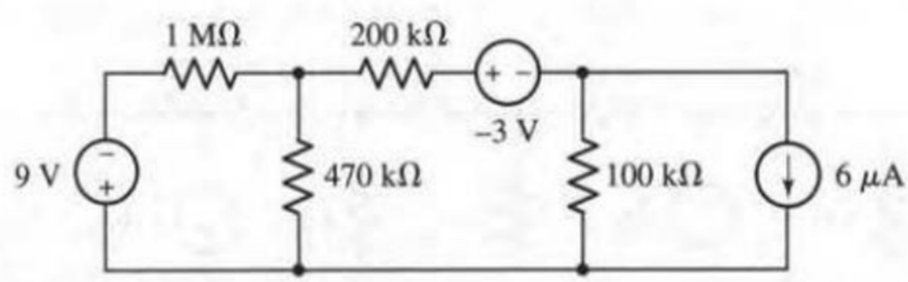
Determine the power dissipated by the 1 MΩ resistor using source transformation to first simplify the circuit shown in Fig. 5.70.



■ **FIGURE 5.70**

Ans: 33.06 μW

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