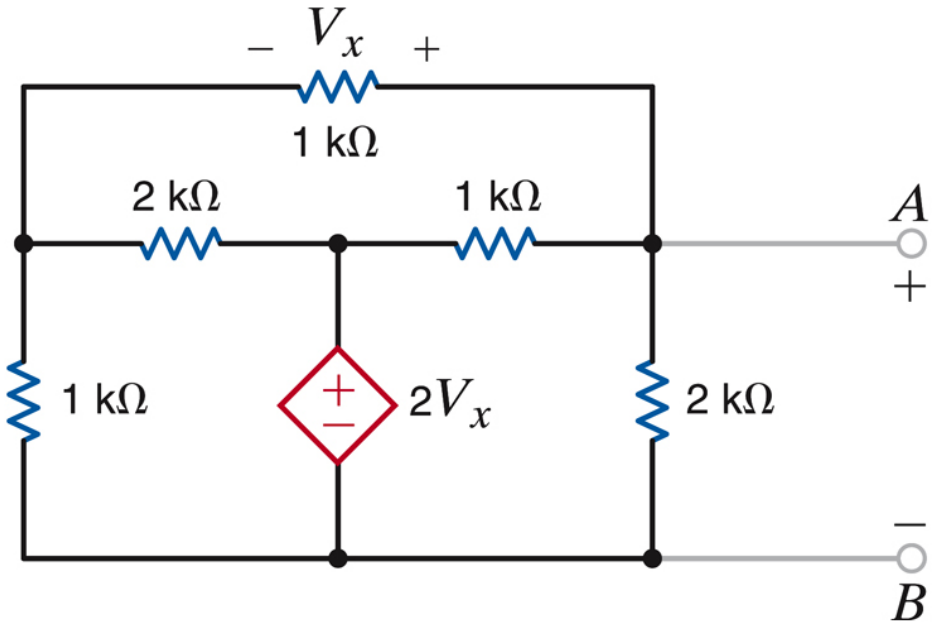
ECE 203

Circuits I

Thévenin and Norton Theorems With Dependent Sources

Lecture 8-2

What is the Thévenin equivalent of this circuit at AB terminal?



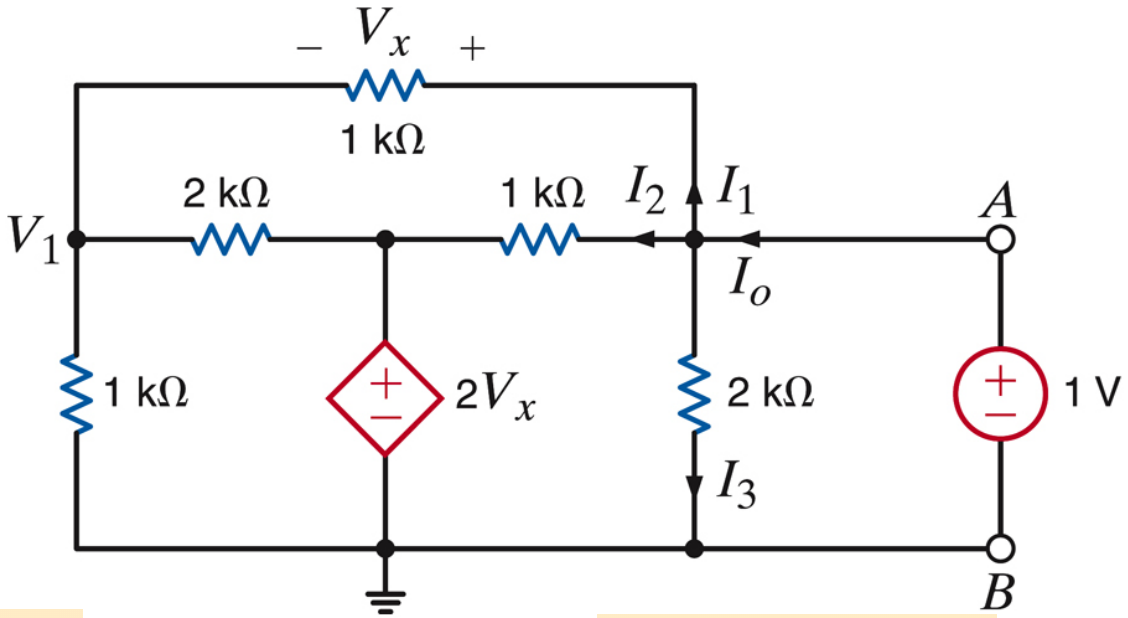
What is the value of V_{oc}? $V_{oc} = 0V$

What is the value of I_{sc}? $I_{sc} = 0A$

What is the value of R_{Th}? $R_{Th} = V_{oc}/I_{sc} = 0/0$!

How to find R_{Th}?

Connect a 1V voltage source at AB terminal and calculate the current flowing back into the circuit



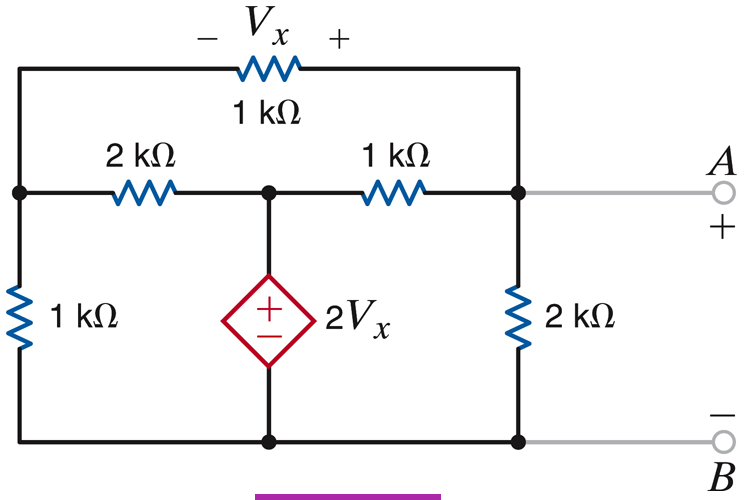
$$\begin{cases} V_1 + V_x = 1 \\ \dfrac{V_1}{1\text{k}} + \dfrac{V_1 - 2V_x}{2\text{k}} + \dfrac{V_1 - 1}{1\text{k}} = 0 \end{cases}$$

$$I_o = I_1 + I_2 + I_3 = \frac{15}{14}\,\text{mA}$$

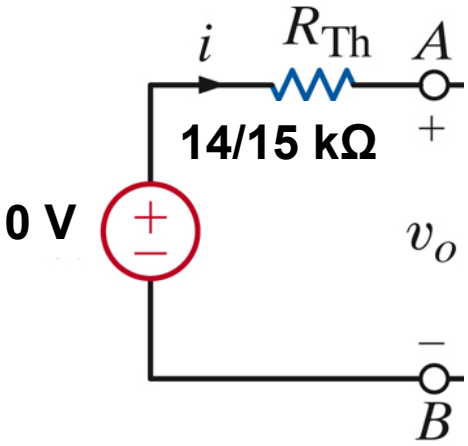
$$R_{\text{Th}} = \frac{1}{I_o} = \frac{14}{15}\,\text{k}\Omega$$

Note: In a circuit with a dependent source, you can't directly calculate the Thévenin resistance.

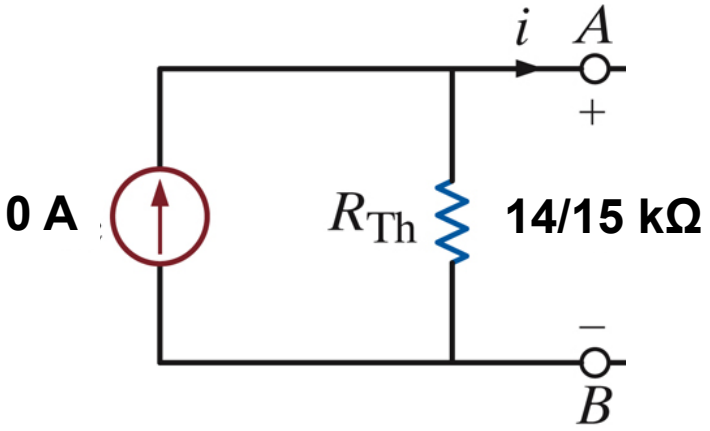
Thévenin's & Norton's Equivalent Currents



Thevenin

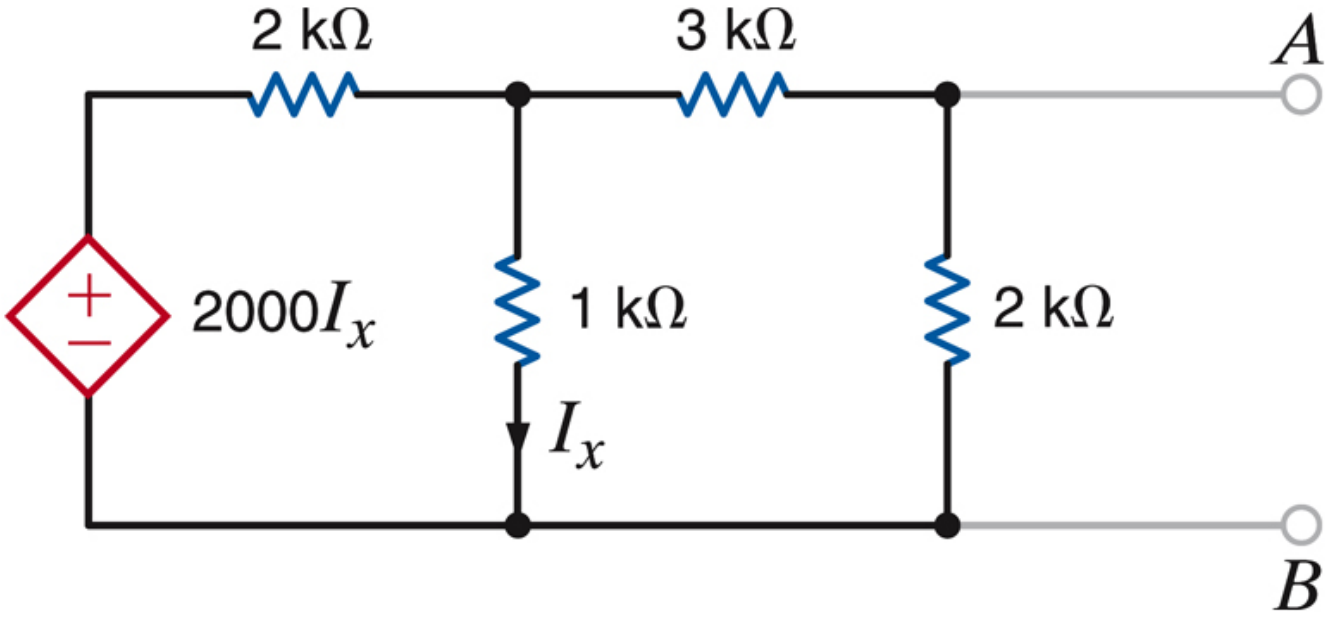


Norton



Yet Another Example:

What is the Thévenin equivalent of this circuit at AB terminal?



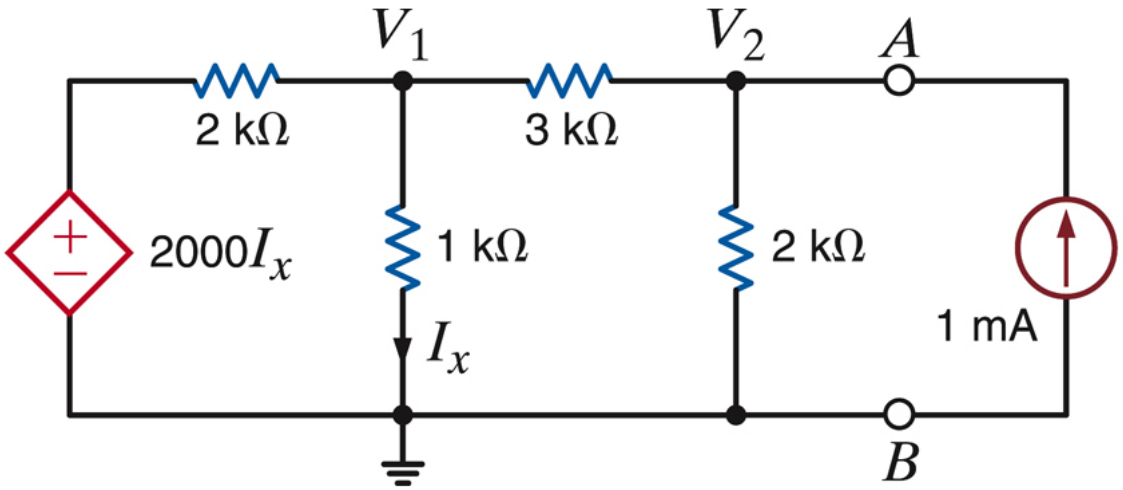
What is the value of V_{oc}? $V_{oc} = 0V$

What is the value of I_{sc}? $I_{sc} = 0A$

What is the value of R_{Th}? $R_{Th} = V_{oc}/I_{sc} = 0/0$!

How to find R_{Th}?

Connect a 1A (or 1mA) current source at AB terminal and measure the voltage



$$\begin{cases} \dfrac{V_1 - 2000I_x}{2\text{k}} + \dfrac{V_1}{1\text{k}} + \dfrac{V_1 - V_2}{3\text{k}} = 0 \\ \dfrac{V_2 - V_1}{3\text{k}} + \dfrac{V_2}{2\text{k}} = 1 \times 10^{-3} \end{cases} \Rightarrow V_2 = \frac{10}{7}\,\text{V} \Rightarrow R_{\text{Th}} = \frac{V_2}{1 \times 10^{-3}} = \frac{10}{7}\,\text{k}\Omega$$

Utility of Thévenin's & Norton's Theorems

- **Thévenin's & Norton's theorems often permit us to break a large problem into several smaller problems.**
- **They allow us to replace a network, no matter how large, at a pair of terminals with Thévenin or Norton equivalent circuit.**
- **In fact, we could represent the entire US power grid at a pair of terminals with one of the equivalent circuits.**

Summary of how to apply Thévenin and Norton Theorems

I. Circuits with all independent sources
   1) Break circuit at point of interest
   2) Calculate $V_{oc} = V_{Th}$; Or, calculate I_{sc}
   3) Short voltage sources and open current sources; calculate R_{Th}

Summary of how to apply Thévenin and Norton Theorems

II. Circuits with only dependent sources

1) Generally don't break the circuit anywhere; usually have an output we are interested in
2) Put test voltage (or current) at output
3) Calculate I_{in} (or Vin) due to test voltage
4) $R_{Th} = V_{test}/I_{in}$ or, $R_{Th} = V_{in}/I_{test}$; There is neither a voltage source nor a current source in the equivalent circuit

Note: Do not short (or open) dependent sources

Summary of how to apply Thévenin and Norton Theorems

III. Circuits with independent and dependent sources

1) Break circuit at point of interest
2) Calculate $V_{oc} = V_{Th}$
3) Calculate I_{sc}
4) $R_{Th} = V_{oc}/I_{sc}$

Note: Do not open (or short) dependent sources

Examples:

Go to examples 8-2.1 thru 8-2.3