MORE NODAL ANALYSIS

Lecture 10 review:

- Ideal and real instruments
- Series and parallel elements
- Nodal analysis with floating voltage sources

Today:

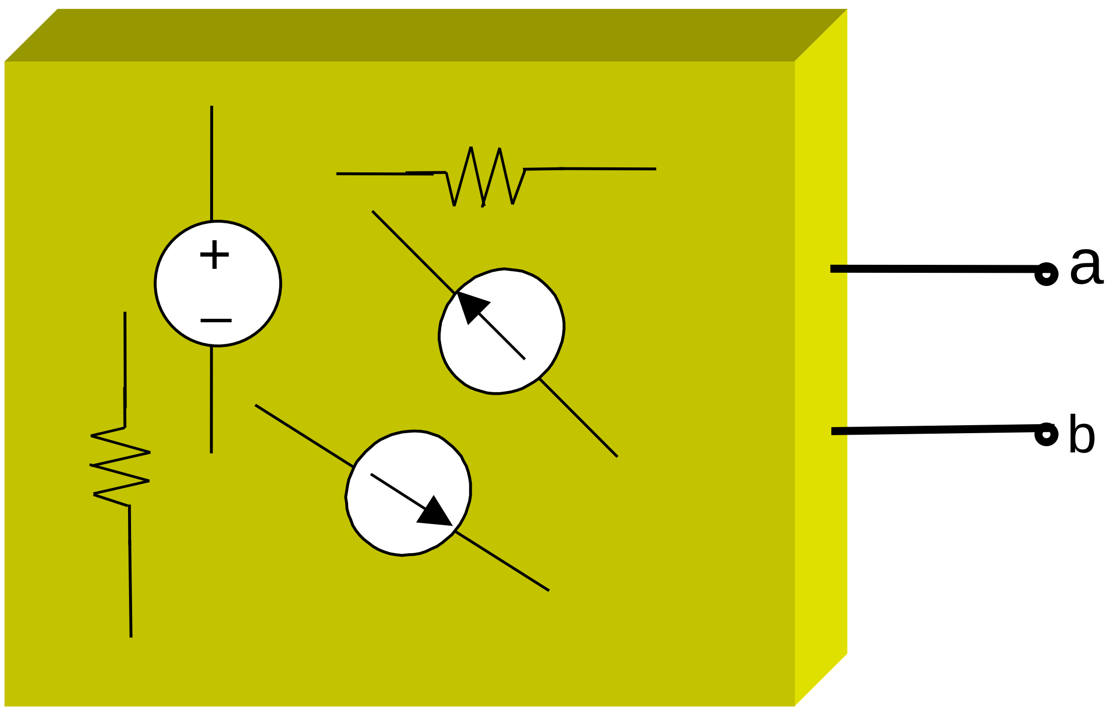
- Special properties of linear circuits:
  - Thevenin and Norton Equivalents
- Examples

Linear Circuits -Special Properties

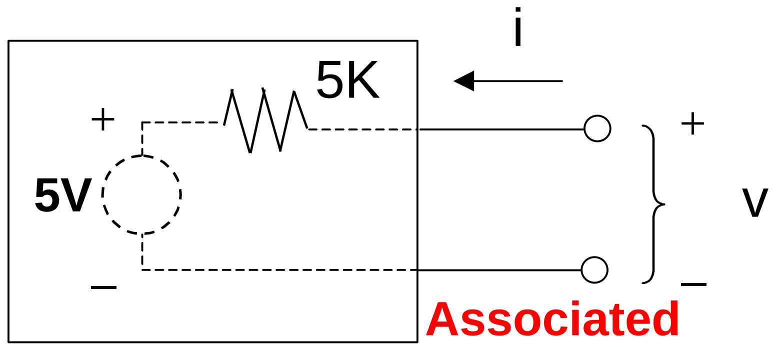
- Circuits consisting only of linear elements are linear circuits.
- There are simple “equivalent circuits” for “one-port” linear circuits.

TWO-TERMINAL LINEAR RESISTIVE NETWORKS
("One Port" Circuit)

Interconnection of two-terminal linear resistive elements with only two "accessible" terminals



I-V CHARACTERISTICS OF LINEAR TWO-TERMINAL NETWORKS



What is the easy way to find the I-V graph?

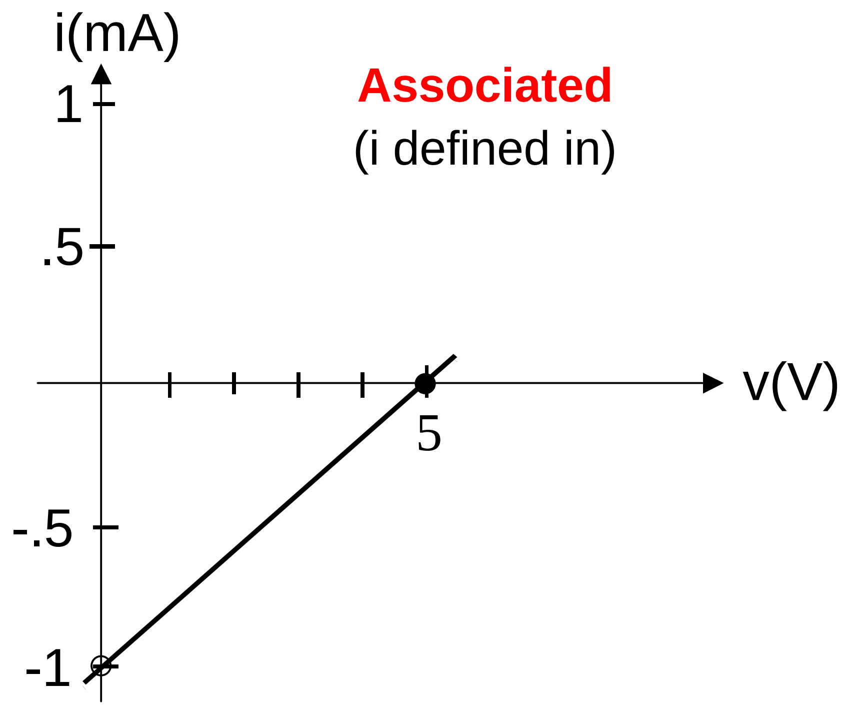
Apply v, measure i, or vice versa

First find open-circuit V

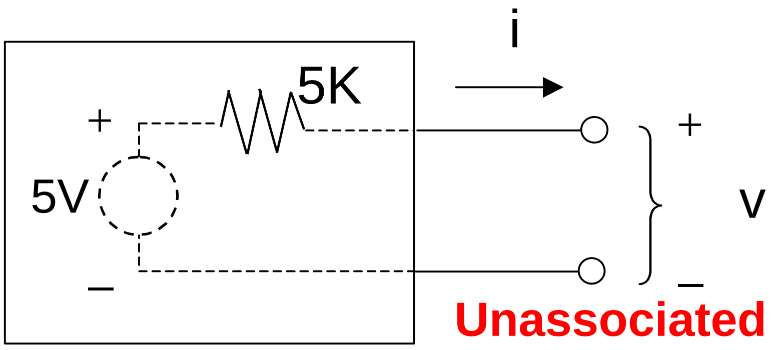
v=5V if i = 0

Now find Short-circuit I

i = -1mA if v = 0



I-V CHARACTERISTICS OF LINEAR TWO-TERMINAL NETWORKS



Lets do same thing but with *unassociated* signs

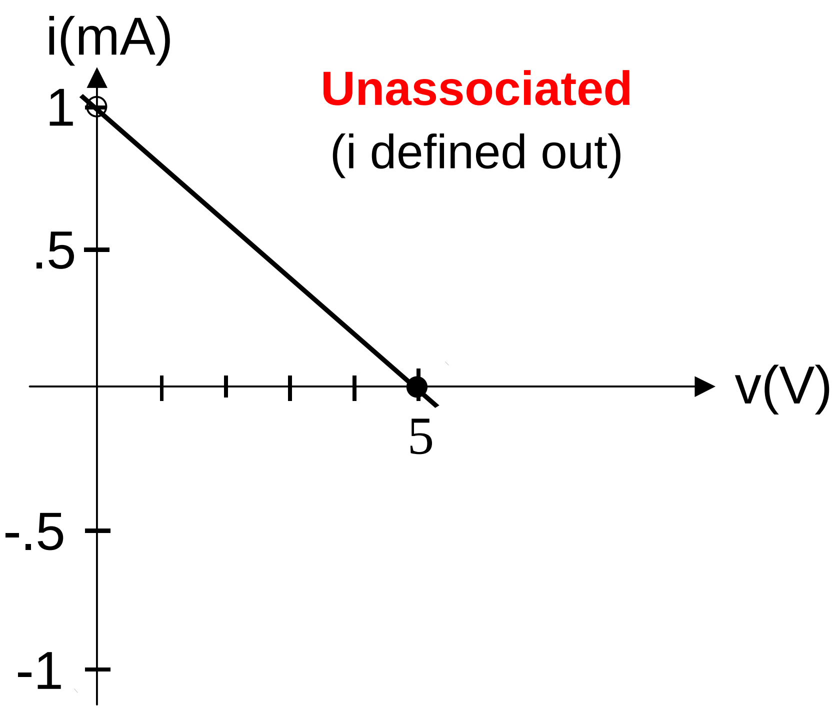
Apply v, measure i,
or vice versa

First find open-circuit V

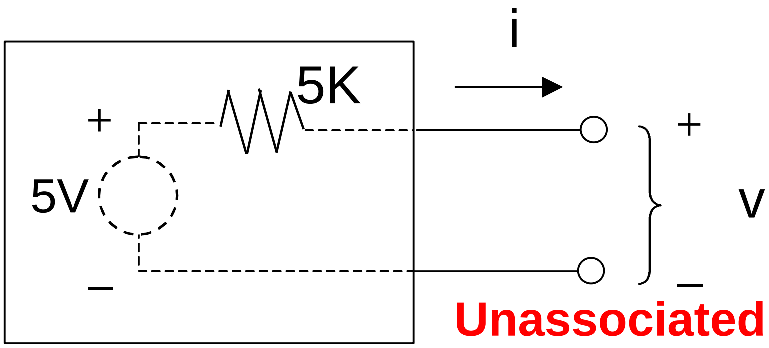
v=5V if i = 0

Now find Short-circuit I

i = +1mA if v = 0

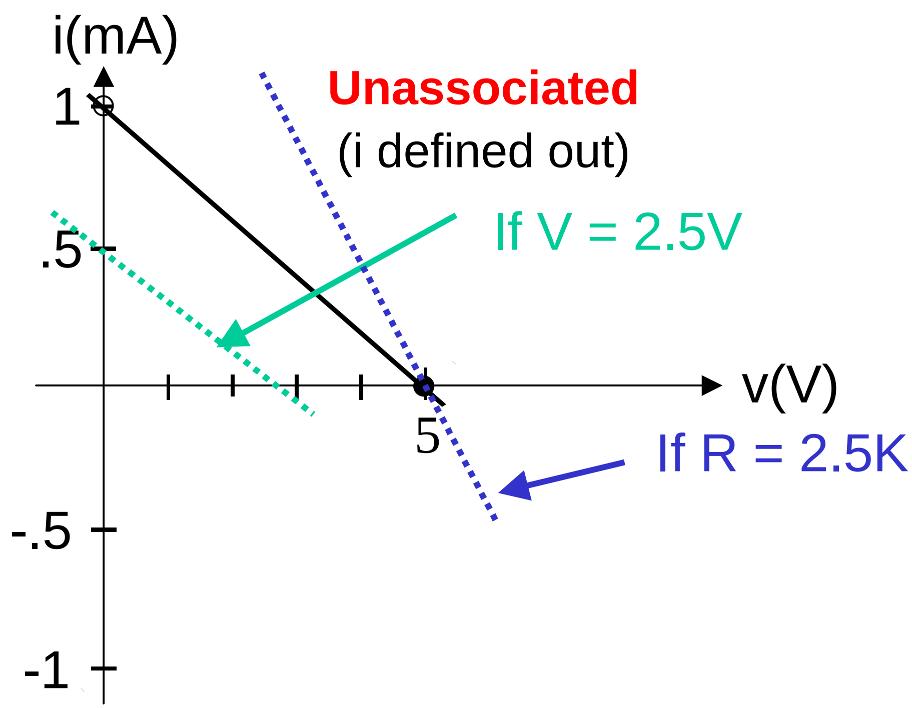


I-V CHARACTERISTICS OF LINEAR TWO-TERMINAL NETWORKS



Consider how the graph changes with differences in V and R.

Apply v, measure i, or vice versa



First consider change in V, eg V= 2.5V, not 5V

Now consider change in R (with V back at 5V)

Clearly by varying V and R we can produce an arbitrary linear graph … in other words this circuit can produce *any* linear graph

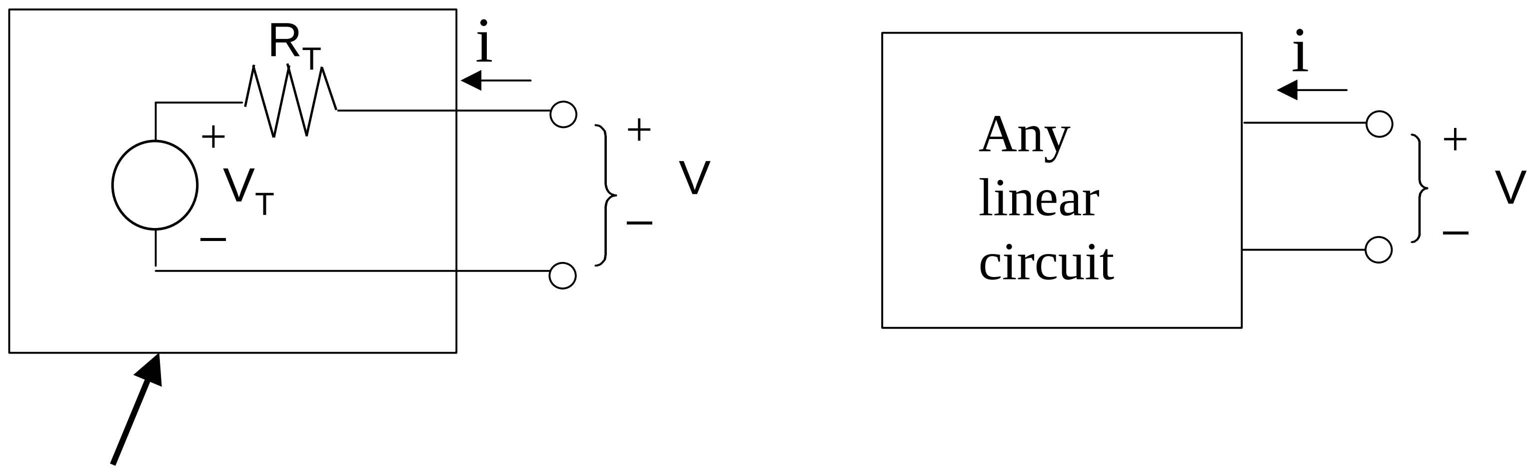
BASIS OF THÉVENIN THEOREM

- **All *linear* one-ports have linear I-V graph**
- **A voltage source in series with a resistor can produce any linear I-V graph by suitably adjusting V and I**

THUS

We define the voltage-source/resistor combination that replicates the I-V graph of a linear circuit to be the Thévenin equivalent of the circuit. The voltage source V_T is called the Thévenin equivalent voltage and the resistance R_T is called the Thévenin equivalent resistance.

Thévenin Equivalent Circuit

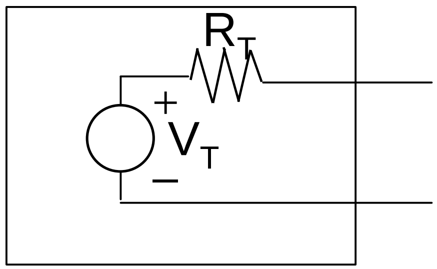


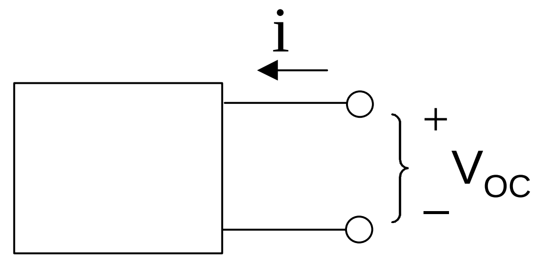
This circuit is equivalent to any circuit, that is by suitably choosing V_T and R_T it will have the same I-V graph

So how do we choose V_T and R_T ?

FINDING V_T, R_T BY MEASUREMENT

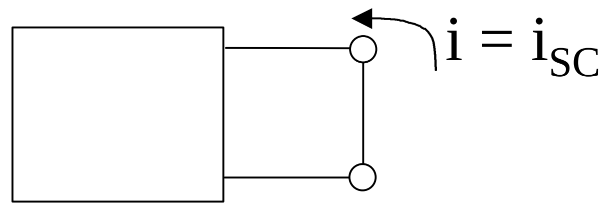
1 V_T is the open-circuit voltage V_{OC} (i.e., i = 0)





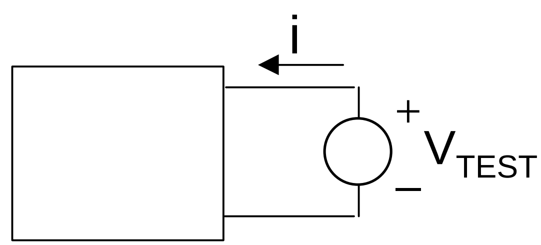
2a) If we short the output clearly $I = -V_T/ R_T$ thus R_T is the ratio of V_{OC} to $- i_{SC}$, the short-circuit current

$$R_T = -\frac{V_{OC}}{I_{SC}}$$



2b) If $V_T = 0$, you need to apply test voltage, then

$$R_T = \frac{V_{TEST}}{i}$$



FINDING V_T, R_T BY ANALYSIS

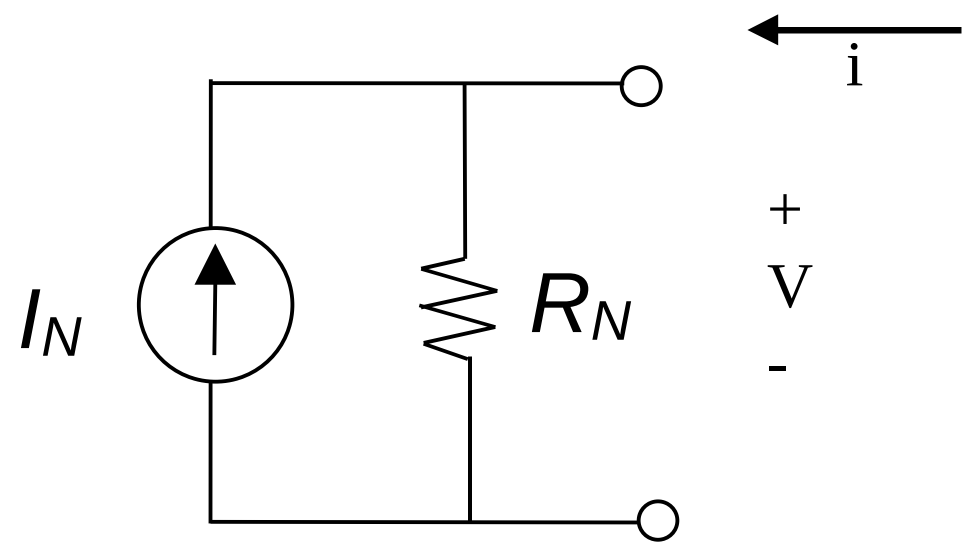
1 Calculate V_{OC}. $V_T = V_{OC}$

2 Turn off all independent sources and find equivalent R at terminals

NORTON EQUIVALENT CIRCUIT

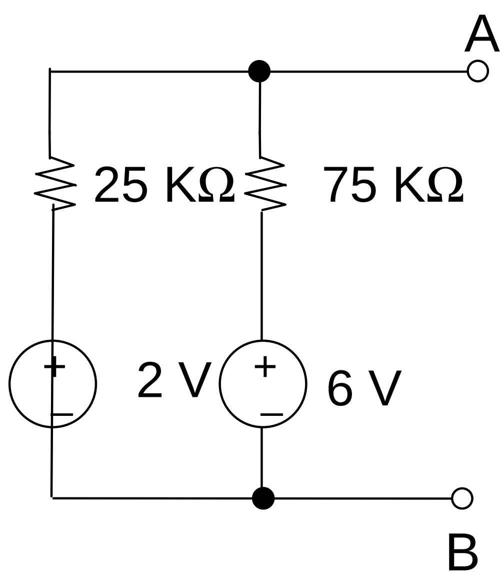
Corollary to Thévenin: $I_N = -I_{SC}$ (short-circuit current) (associated)

R_N is found the same way as for Thévenin equivalent



EXAMPLE

Find the Thévenin and Norton equivalents of:



Find $V_{AB} = V_{OC}$ from voltage divider. Left to right:

(4 V rise across 25K + 75K) ⇒

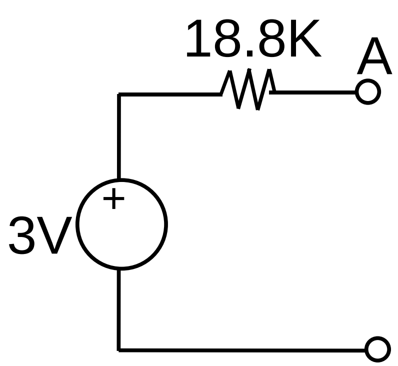
3 V across 75K, 1 V across 25k.

So, $V_{AB} = -3 + 6 = 3V = V_{OC}$

I_{SC} = - 6V/75K+2V/25K = -0.16 mA

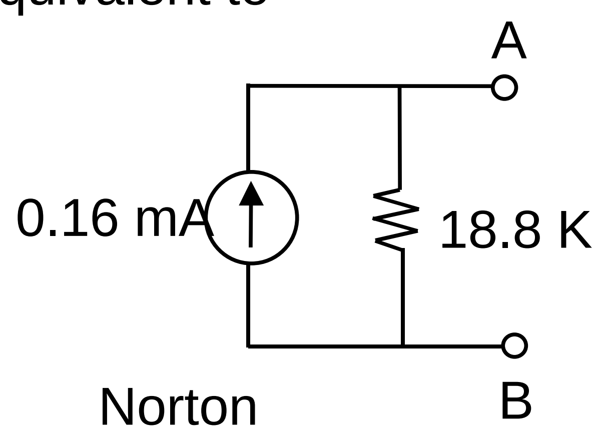
$$R_{TH} = \frac{3}{.16 \times 10^{-3}} = 18.8K$$

equivalent to



Thévenin

and equivalent to



Norton