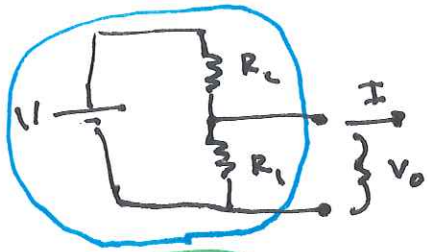
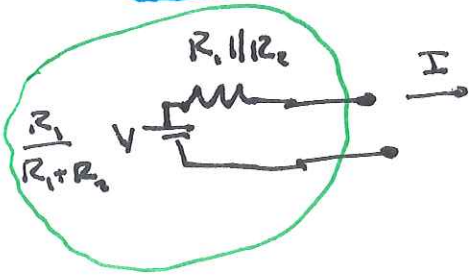


$$V_0 = \frac{R_1}{R_1+R_2}V - R_1\|R_2\, I$$



$$V_0 = \overbrace{\frac{R_1}{R_1+R_2}V}^{\text{Thevenin equivalent voltage } V_{TH}} - \overbrace{R_1\|R_2}^{\text{Thevenin equivalent resistance } R_{TH}} I$$

From the point of view of the two selected terminals whats inside blue circle acts exactly like whats inside the green circle. Thevénin Thm:

Any two terminal network consisting of resistors, fixed voltage/current sources and linear dependent sources is externally equivalent to a circuit consisting of a resistor in series with a fixed voltage source.

Generalize to one frequency AC systems with LRC.

Most any properly operating system — even if it has nonlinear active devices like transistors — also follows this thm at least in a 1st order Taylor Series sense.

The "resistor" is called the Thevenin equivalent resistor or output impedance; the "fixed voltage source" is called the Thevenin equivalent voltage source.

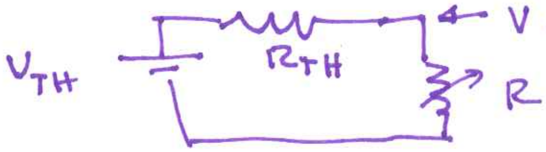
In simple cases you can mathematically determine R_{TH} by replacing voltage sources with wires ($\to$)

[this is sometimes described as "shorting out the batteries" which is something you would never do actually]

and replacing current sources with disconnects ($\to$) and finding the resulting resistance between the terminals

You can mathematically determine V_{TH} by calculating the voltage between the terminals with no current drawn from those terminals.

In the lab determine V_{TH} by just measuring the voltage between the terminals with a DMM. Determine R_{TH} by attaching a variable resistor between the terminals and adjusting that resistance until a DMM measures $\frac{1}{2}$ of what it did with no load applied.



← $V = \frac{1}{2} V_{TH}$ ← then $R = R_{TH}$

Or just attach any R and measure the resulting "voltage droop" ΔV, then $R_{TH} = \dfrac{R}{\frac{V_{TH}}{\Delta V} - 1}$

In HH terms if ΔV is "small", R_{TH} will be "small" and we have a "stiff" voltage source.

Mathematically another way to find R_{TH} is to connect the two terminals with a wire and – using Kirchhoff's Laws – find the current flowing thru that wire then: $R_{TH} = \dfrac{V_{TH}}{I}$

Brief Pf Thevenin – if we look at the structure of the Kirchhoff's Laws eqs they look like.

$$\underbrace{V_1 - V_2 + V_3}_{\text{voltage sources}} = R_5 I_5 - R_6 R_6$$

$$I = I_1 + I_2 - I_3$$

external current source.

A current/voltage source may occur in the lhs of several eqs but in general we have

$$\underbrace{\begin{bmatrix} \\ \\ \\ \end{bmatrix}}_{\substack{\text{column of} \\ \text{fixed sources} \\ \shortparallel \\ S}} = \underbrace{\begin{bmatrix} & & & \\ & & & \\ & & & \end{bmatrix}}_{\substack{\text{matrix of} \\ R\text{s} \\ \shortparallel \\ M}} \underbrace{\begin{bmatrix} \\ \\ \\ \end{bmatrix}}_{\substack{\text{column of unknown} \\ \text{currents} \\ \shortparallel \\ I}}$$

so. $M^{-1} S = I$

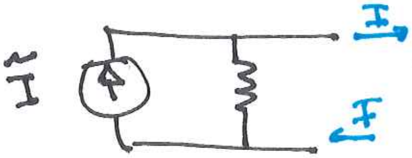
this says any particular current (eg I_5) is a linear combination of the sources –

$(\text{eg } I_5 = 6 V_3 - 2I)$

This is sometimes called the superposition Thm – If you solve the problems of the circuit with just one source on at a time you can solve the actual problem just by adding up those solutions

In any case if the currents satisfy this linear relationship the voltage at any node must also and hence the voltage difference between our two terminals – Thus $\Delta V = \text{const} - \text{const} \cdot I$ where I is the current we pull from the terminals.

Norton's Thm: "Any" circuit is also equivalent to a current source in parallel to a resistor



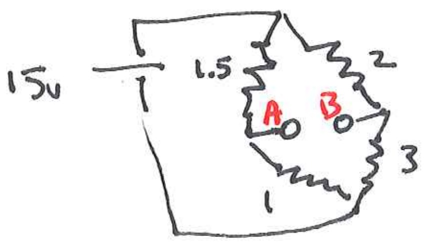
$$\Delta V = R_N(\tilde{I} - I)$$
$$= R_N\tilde{I} - R_N I$$

we know from Thevenin $\Delta V = V_{TH} - R_{TH} I$

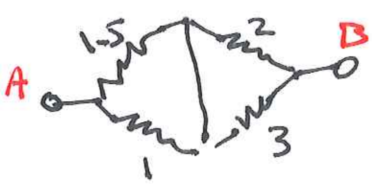
so things match if $R_N = R_{TH}$

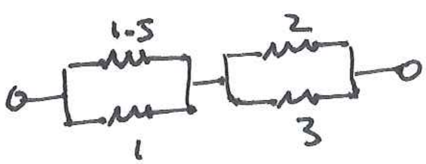
$$\tilde{I} = \frac{V_{TH}}{R_N}$$

Example Thevenin

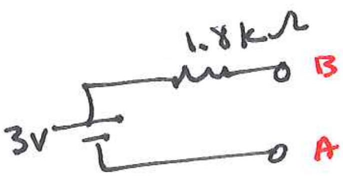


$$\left.\begin{array}{l} V_A = \frac{1}{2.5} 15 = 6V \\ V_B = \frac{3}{5} 15 = 9V \end{array}\right\} V_{TH} = 3V$$





$$R_{TH} = \frac{1.5 \cdot 1}{2.5} + \frac{2 \cdot 3}{5} = 1.8\,k\Omega$$



if connect A & B with $3k\Omega$

$$I = \frac{3V}{4.8k\Omega} = .625\,mA$$