1 Recipe: Superposition/Equivalent Circuits

1.1 Superposition Theorem

The saying: the result of one element is the sum of all the contributing members.

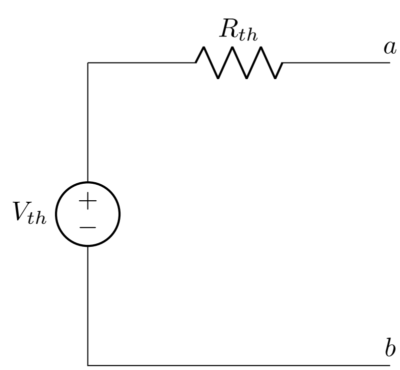
1.1.1 Directions

1. **Isolate one independent source.** Other voltage sources turn into wires and current sources turn into open circuits.
2. **Use NVA** to solve for the contributing voltage/current.
3. **Repeat**
4. V_{total} and I_{total} *for that element* are going to be the sum of the contributing currents/voltages.

1.2 Equivalence

1.2.1 Thevenin Equivalence

Basically, any constant and linear circuit can be simplified down to just a voltage source and a resistor.

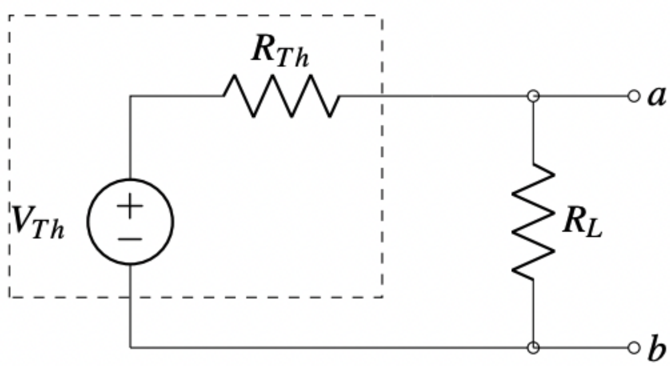


1.2.2 Thevenin Load Resistor

When calculated correctly, R_L cannot tell the difference between our Thevenin Equivalent circuit and the original circuit, no matter how we change its resistance. Both circuits will have the same V_{load} and I_{load} for any R_L. Please draw the distinctive line between the blackbox and our load resistor. It may change the voltage potentials and currents inside the blackbox too, but we've abstracted out that complexity and don't worry about that.

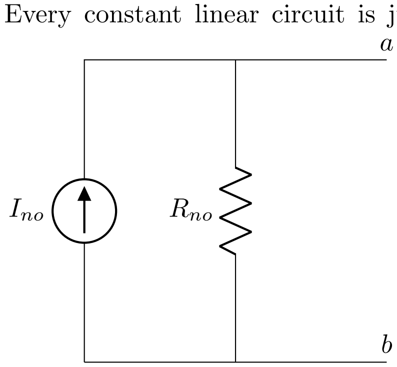
You may think that adding a load resistor will change our V_{th} / I_{no}. This is technically true if you'd redraw your Thevenin circuit to include the load resistor. However, we do not include the load resistor in our Thevenin black box. Hence, our equivalent circuit remains constant.

V_{th} can be variable in respect to time. But $V_{th}(t)$ has to end up with the same linear IV relationship of $V_{ab}(t)$ with the original.



1.2.3 Norton Equivalence

Every constant linear circuit is just a current source and a parallel resistor.



1.3 Solving for the Equivalent Circuit

Note: no load resistor exists for any of these methods.

1.3.1 Method 1 - V_{test} and I_{test}

1. Plug in V_{test} or I_{test} depending on circuit.
    - With a current source, you can take advantage of series resistors having the same current.

- With a voltage source, you can take advantage of parallel resistors having the same voltage difference.

2. Find I_{test} if you used V_{test}, vice versa.
3. R_{eq} is V_{test}/I_{test}

1.3.2 Method 2 - V_{th} and I_{no}

1. Find V_{th} by attaching a voltmeter. Then use simplifications and/or NVA.
2. Find I_{no} by attaching an ammeter. Then use simplifications and/or NVA.
3. R_{th} or R_{no} is just V_{th}/I_{no}

1.3.3 Method 3 - If there are no dependent sources

1. Deactivate all independent sources. Then find the R_{eq} of the black box.
2. Either find V_{th} or I_{no} by attaching a voltmeter or current source.
3. Find the other via $V_{th} = R_{eq}I_{no}$

1.4 Capacitor Equivalence

1.4.1 Method 1 - Apply I_{test} and Measure $\frac{dV_{test}}{dt}$

Use this when we know the voltages are the same.

1.4.2 Method 2 - Apply $\frac{dV_{test}}{dt}$ and measure I_{test}