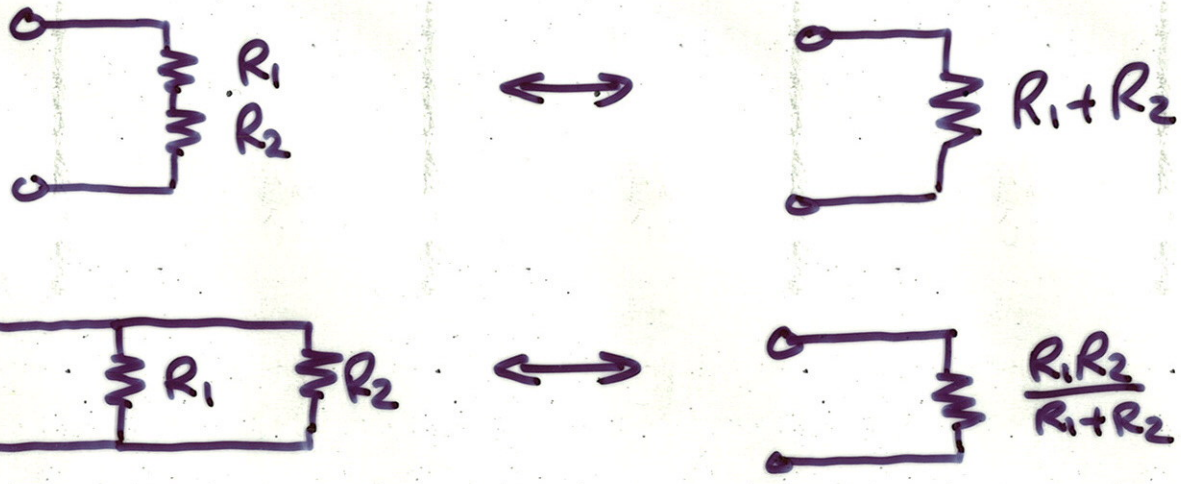
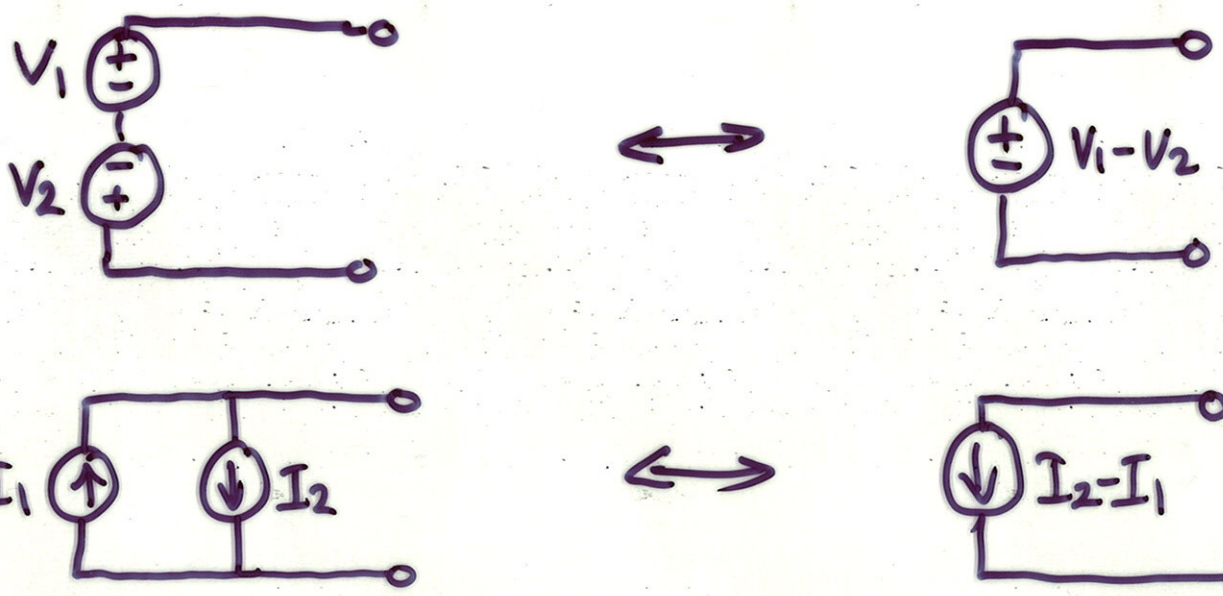
Additional Tools for Gen. Circuit Analysis

- Node & Mesh: Comprehensive, can be complicated
- New tools that can reduce complexity
  - simple equivalents
  - superposition
  - Thevenin & Norton equivalents

Simple Equivalent Circuits

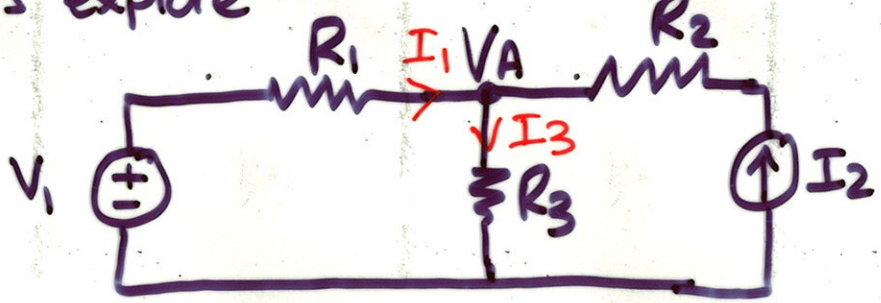
- What do we already know?





Linearity

- I said that this can simplify analysis
- Let's explore



Find V_A.

Node or Mesh?

Let's try node

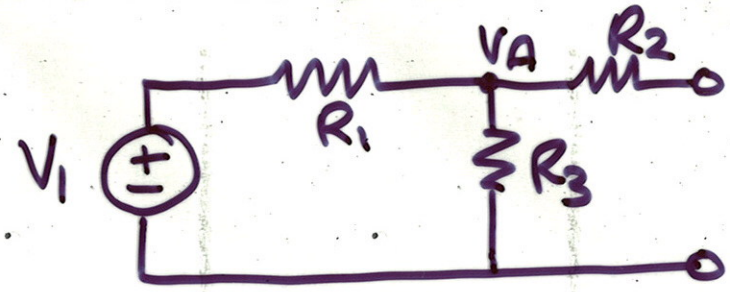
KCL at A: $I_1 + I_2 = I_3$

Ohm's Law $I_1 = \frac{V_1 - V_A}{R_1}$

$I_3 = V_A / R_3$

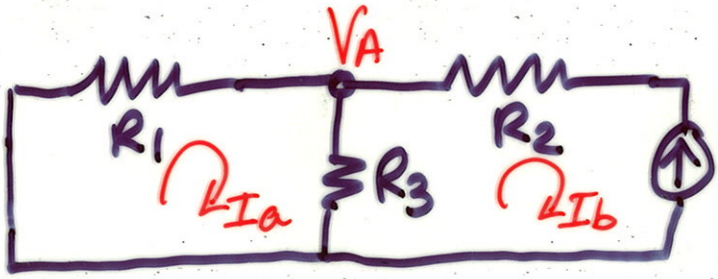
$$\Rightarrow V_A = \frac{R_3}{R_1+R_3} V_1 + \frac{R_1 R_3}{R_1+R_3} I_2$$

Some related circuits:



KCL at A, (or voltage division)

yields $V_A = \frac{R_3}{R_1+R_3} V_1$



$I_b = -I_2$

KVL loop a: $R_1 I_a + R_3 (I_a - I_b) = 0$

$\Rightarrow V_A = -R_1 I_a = \frac{R_1 R_3}{R_1+R_3} I_2$

Looks interesting

Principle of Superposition

- we have discovered one instance of a broader result:
- **Principle of superposition**

For any ~~one~~ linear circuit with multiple independent sources,

the current or voltage at any point in that circuit

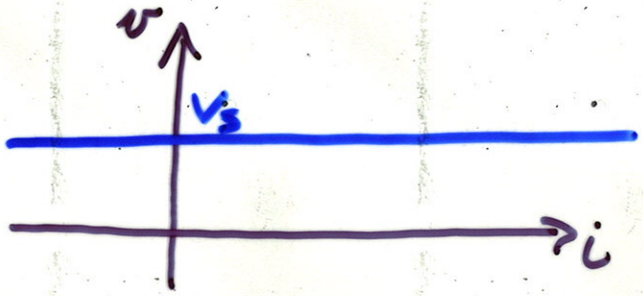
is the algebraic sum of the current or voltage due to each source acting alone

(ie all others "turned off")

(independent sources)

How do we model "turned off"?

Ideal Independent voltage source



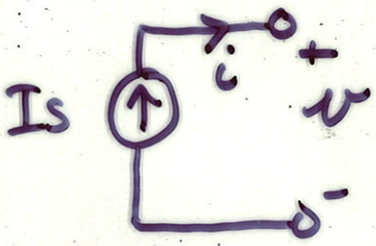
Same voltage nomatter what the current.

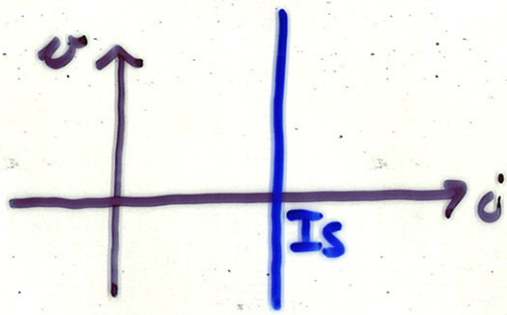
What is "off"? $V_s = 0$

⇒ "off" means zero voltage regardless of current

⇒ short circuit

Ideal Independent Current Source





Same current no matter what the voltage

what is "off"? $I_s = 0$

⇒ "off" means no current regardless of voltage

⇒ open circuit

Recipe for Superposition

1. Desired current or voltage is algebraic sum of current or voltage due to each independent source acting alone (all other independent sources "turned off")

2. Draw circuit with all but one independent sources turned off; i.e.,
   - Replace indep. voltage sources by SC
   - Replace indep. current sources by OC
   - DO NOT turn off dependent sources

3. Solve circuit

4. Repeat for other sources.
   If there are N independent sources, we will need N circuits

5. Take algebraic sum to obtain answer

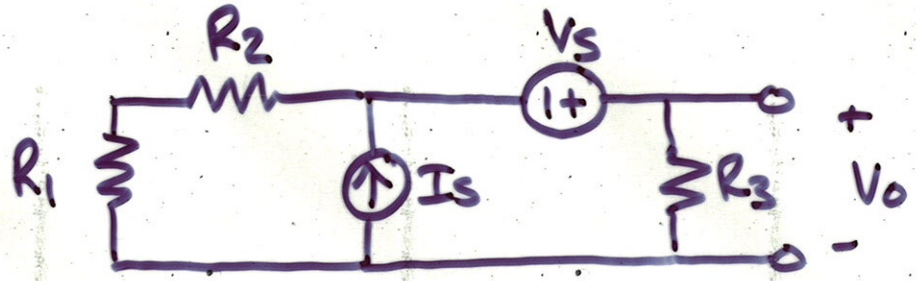
Notes on Recipe

- We did one source at a time, but they can be grouped in an arbitrary fashion
- This approach is not always simpler.

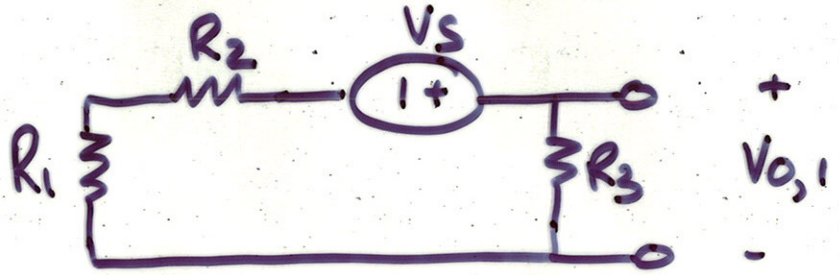
  However

  - very useful in developing intuition
  - very useful in design

EXAMPLE

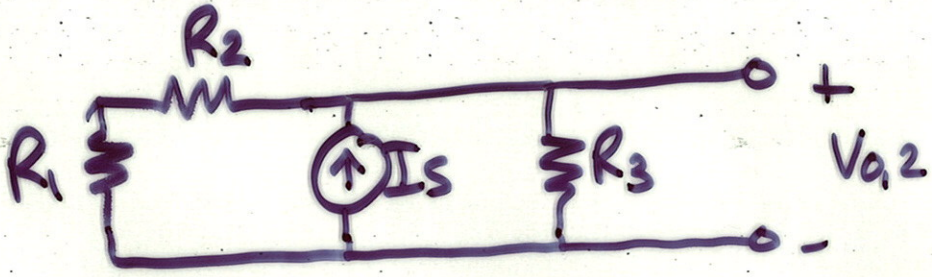


- Draw circuit for Vs alone
  Is = OC



Find $V_{o,1}$ by KVL

- Draw circuit for Is alone



Find $V_{o,2}$ by KCL

$$V_o = V_{o,1} + V_{o,2}$$