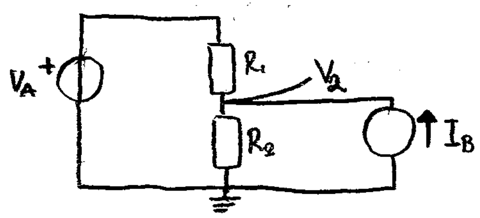
Superposition

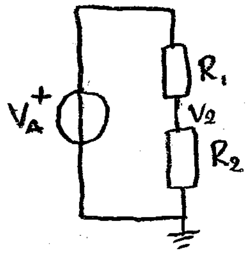
- A linear system obeys the principle of superposition.
- If we have several sources the total response of the circuit is equal to the sum of the responses from each source.

Ex:



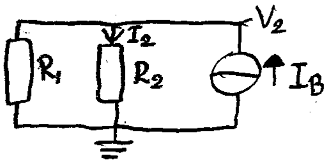
Determine V_2

① Calculate response from V_A alone.
(Turn off I_B, $I_B = 0$ "OPEN")



$$V_2 = V_2 \frac{R_2}{R_1 + R_2}$$

② Calculate response from I_B alone (Turn off V_A, $V_A = 0$ "short")



$$V_2 = R_2 \cdot I_2 = R_2 \frac{R_1}{R_1 + R_2} I_B = \frac{R_1 R_2}{R_1 + R_2} I_B$$

① + ② $\quad V_2 = V_A \dfrac{R_2}{R_1 + R_2} + \dfrac{R_1 R_2}{R_1 + R_2} I_B$

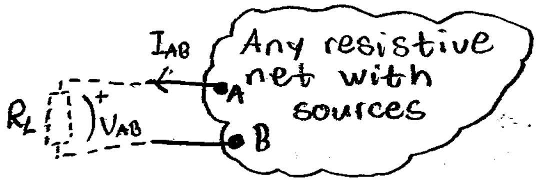
Let's do Node-Voltage for comparison

$$\frac{V_A - V_2}{R_1} + \frac{0 - V_2}{R_2} + I_B = 0$$

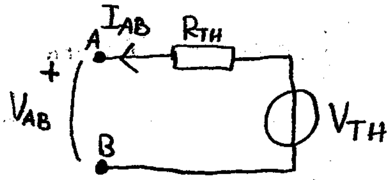
$$\frac{V_A}{R_1} + I_B = \frac{V_2}{R_1} + \frac{V_2}{R_2} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) V_2 \Rightarrow V_2 = \frac{1}{R_1\left(\frac{1}{R_1} + \frac{1}{R_2}\right)} V_A + \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} I_B =$$

$$= \frac{\cancel{R_1} R_2}{\cancel{R_1}(R_1 + R_2)} V_A + \frac{R_1 R_2}{R_1 + R_2} I_B$$

Thevenin Equivalents

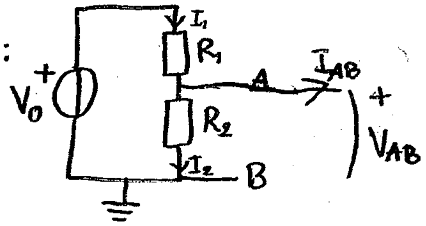


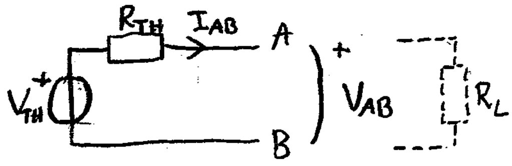
can be described by



if we are only interested in the behavior of the terminals.

Ex:





$$V_{AB} = V_{TH} - R_{TH} \cdot I_{AB} \quad (1)$$

(NOTE: if $I_{AB} = I_{SC}$ $\Rightarrow V_{TH} = R_{TH} \cdot I_{SC}$)

$$I_{AB} = I_1 - I_2 = \frac{V_0 - V_{AB}}{R_1} - \frac{V_{AB}}{R_2} = \frac{V_0}{R_1} - \left(\frac{1}{R_1} + \frac{1}{R_2}\right) V_{AB} = I_{AB}$$

$$V_{AB}\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V_0}{R_1} - I_{AB} \Rightarrow V_{AB} = \frac{V_0}{R_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right)} - \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}} I_{AB} = \frac{V_0}{R_1\left(\frac{R_1+R_2}{R_1R_2}\right)} - \frac{1}{\frac{R_1+R_2}{R_1R_2}} I_{AB} =$$

$$= \frac{R_2}{R_1+R_2} V_0 - \frac{R_1R_2}{R_1+R_2} I_{AB} \quad (2)$$

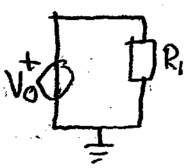
Compare (1) and (2) $\Rightarrow V_{TH} = V_0 \frac{R_2}{R_1+R_2}$ and $R_{TH} = \frac{R_1R_2}{R_1+R_2}$

This was method ① ALWAYS WORKS!

Method 2

- We see that if $I_{AB} = 0$ then $V_{AB} = V_{TH}$
- We see that if $I_{AB} = I_{SC}$ (the short circuit current) then $V_{AB} = 0$ which implies $R_{TH} = \frac{V_{TH}}{I_{SC}}$,

① OPEN $V_{TH} = V_0 \frac{R_2}{R_1+R_2}$ ② Short terminals



$I_{SC} = \frac{V_0}{R_1}$

$$R_{TH} = \frac{V_{TH}}{I_{SC}} = \frac{V_0 \frac{R_2}{R_1+R_2}}{\frac{V_0}{R_1}} = \frac{R_1 \cdot R_2}{R_1+R_2} \quad R_1 // R_2$$

ALWAYS WORKS!

Method 3

① OPEN FIND V_{TH} (Same as in method 2)

② Zero all sources (Voltage source is short and current source is open)

Find R_{TH} looking into the terminals A & B.

$$R_{TH} = R_1 // R_2 = \frac{R_1 R_2}{R_1+R_2}$$