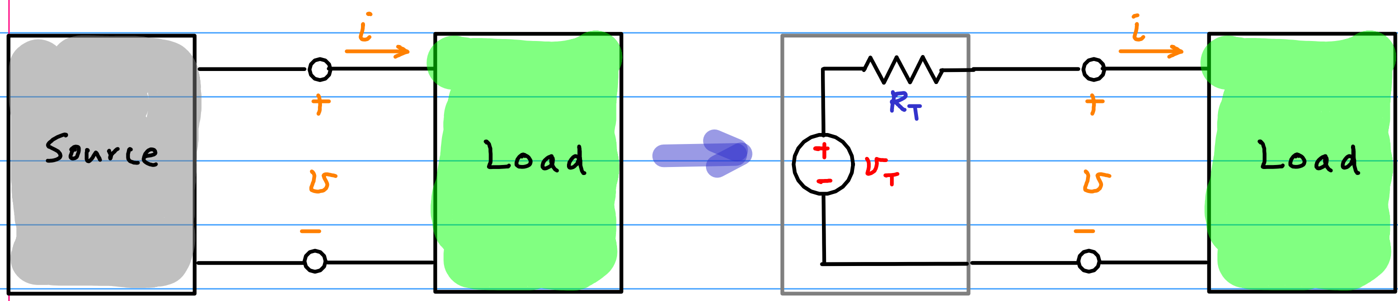
Thevenin & Norton Equivalent Circuits (H.1)

20170315

Thevenin & Norton Theorem

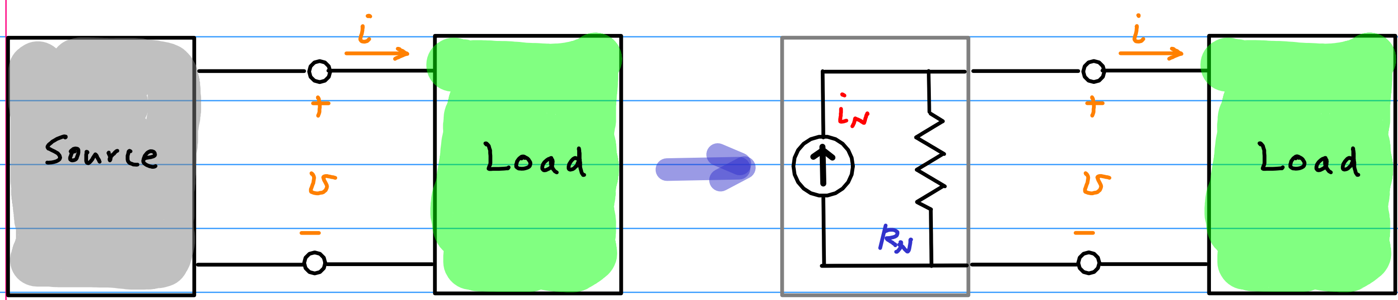
Thevenin's Theorem



$v_T = v_{oc}$ when $i = 0$ $\boxed{\text{max } v}$

$R_T = R_N$

Norton's Theorem

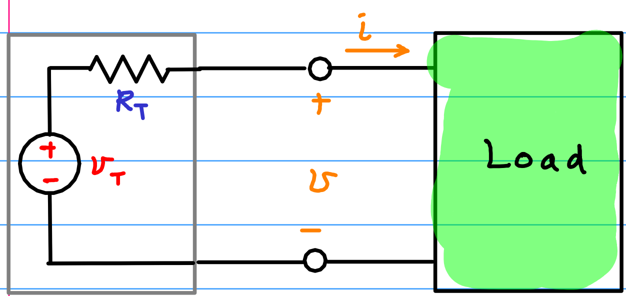


$i_N = i_{sc}$ when $v = 0$ $\boxed{\text{max } i}$

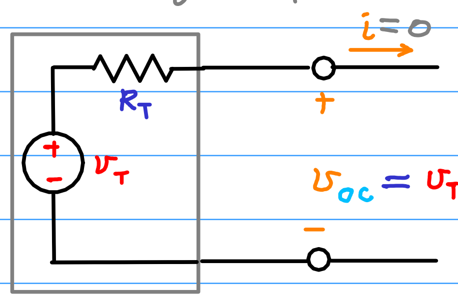
$R_N = R_T$

Max v and Max i conditions

Thevenin's Theorem



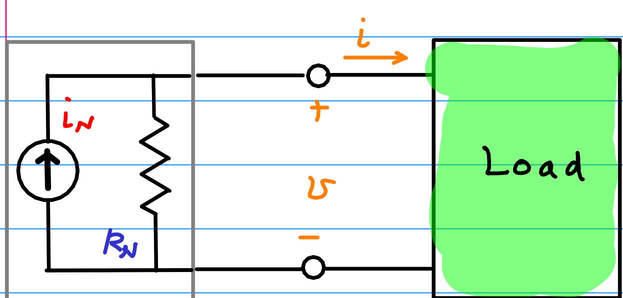
no voltage drop

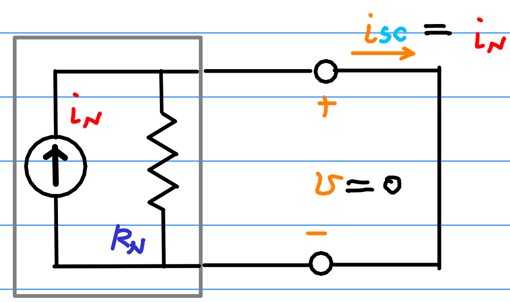


$v_T = v_{oc}$ when $i = 0$ $\boxed{\text{max } v}$ $\boxed{\text{max } v}$ when O.C. ($R_L = \infty$)

$R_T = R_N$

Norton's Theorem

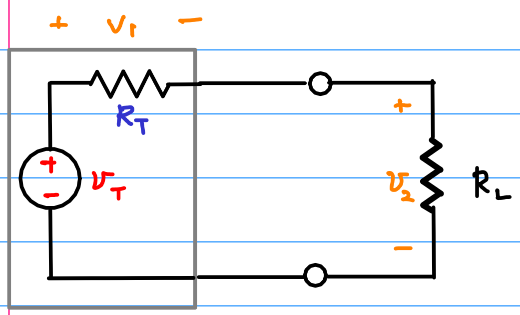




$i_N = i_{sc}$ when $v = 0$ $\boxed{\text{max } i}$ $\boxed{\text{max } i}$ when S.C ($R_L = 0$)

$R_N = R_T$

voltage divider

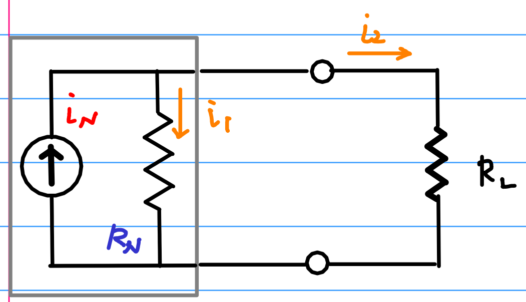


$$v_1 = \frac{R_T}{R_T + R_L} v_T$$

$$v_2 = \frac{R_L}{R_T + R_L} v_T$$

$$\lim_{R_L \to \infty} v_2 = v_T$$

current divider



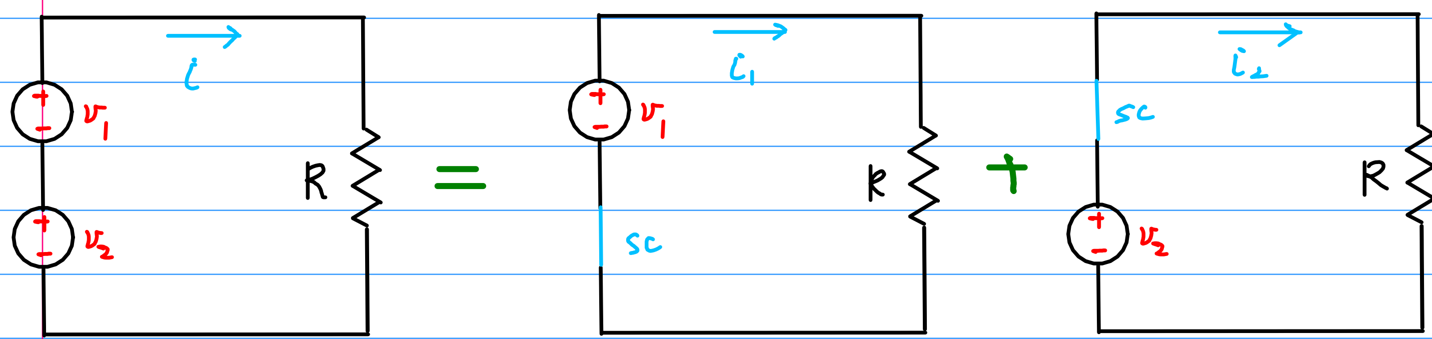
$$i_1 = \frac{R_L}{R_N + R_L} i_N$$

$$i_2 = \frac{R_N}{R_N + R_L} i_N$$

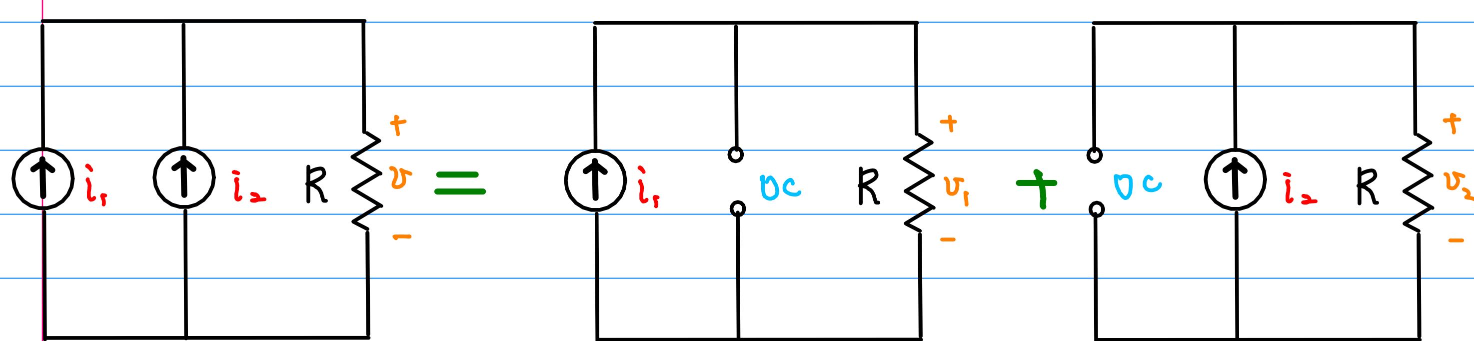
$$\lim_{R_L \to 0} i_2 = i_N$$

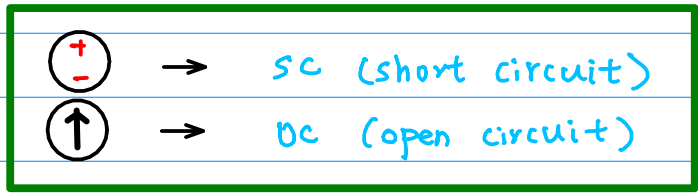
Superposition

$\boxed{i = i_1 + i_2}$



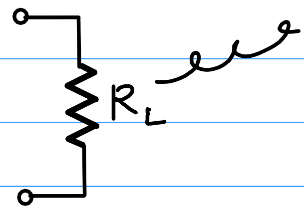
$\boxed{v = v_1 + v_2}$



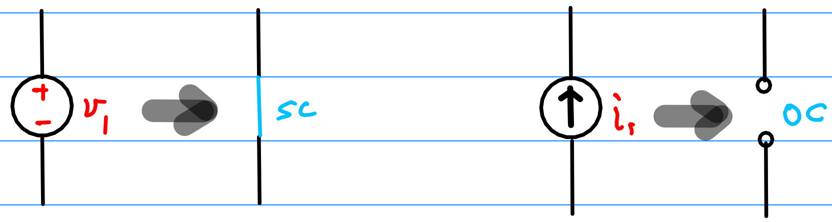


Equivalent Resistance $R_T = R_N$

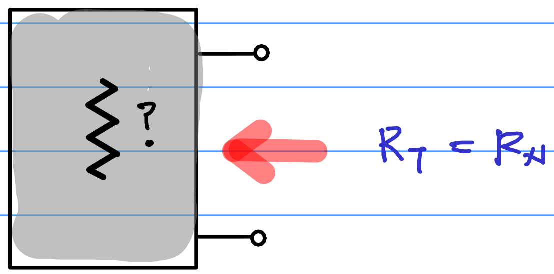
① remove R_L

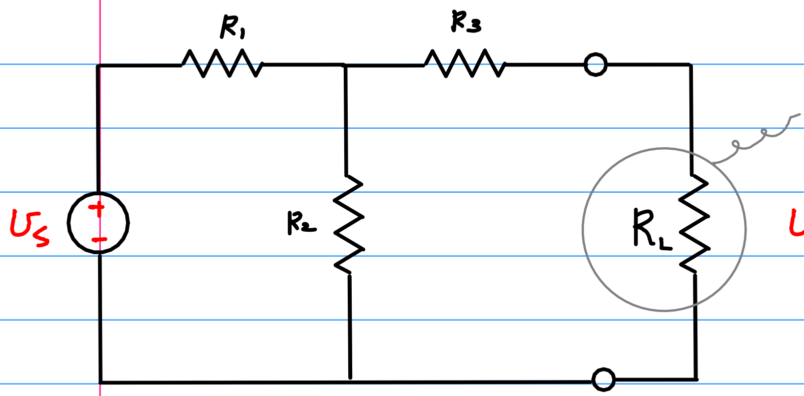


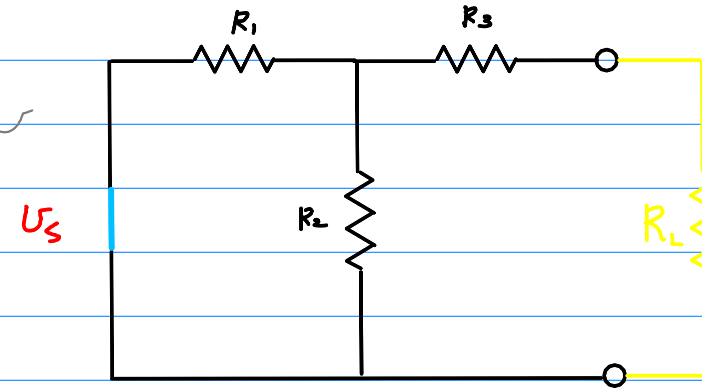
②

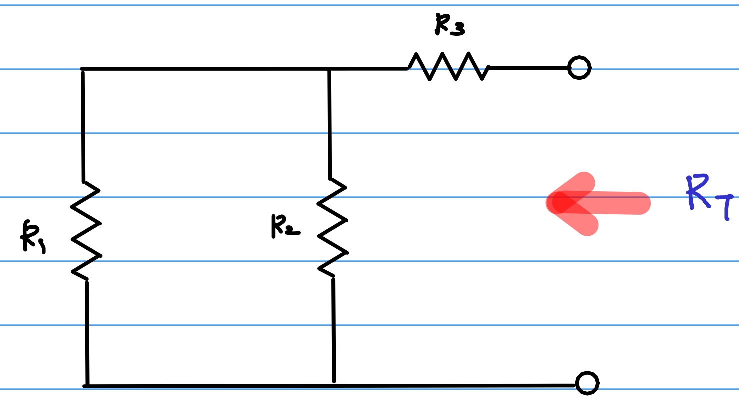


③ resistance seen from the R_L side

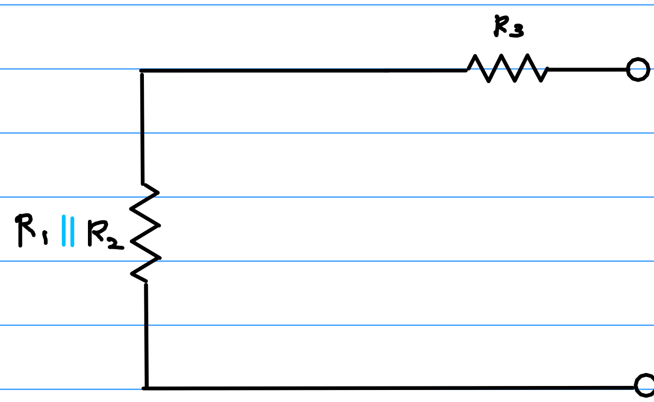






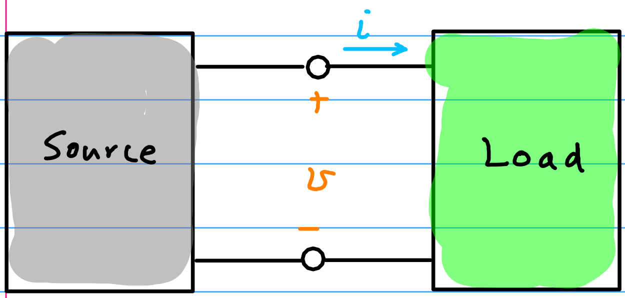


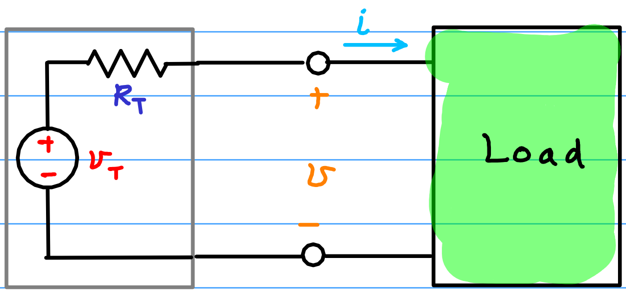
$$R_T = R_1 \parallel R_2 + R_3$$

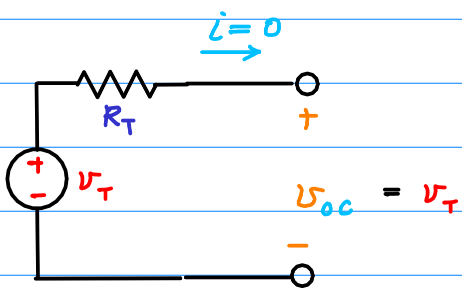


Thevenin voltage v_T

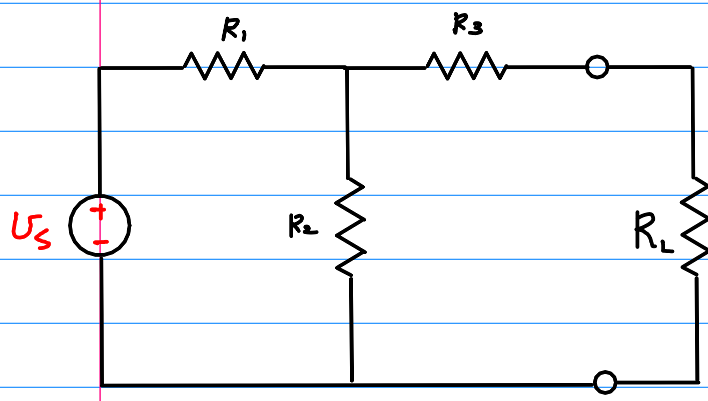
$\boxed{\max v}$

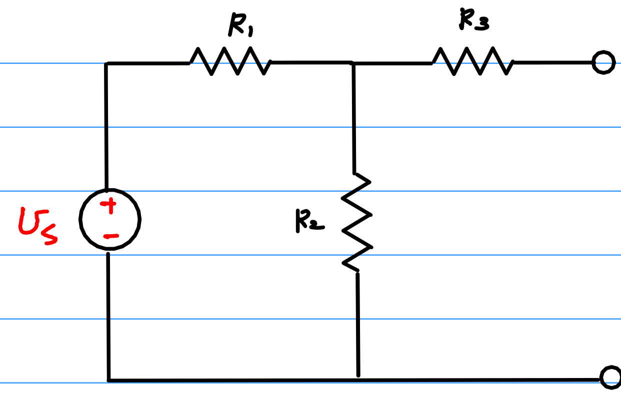


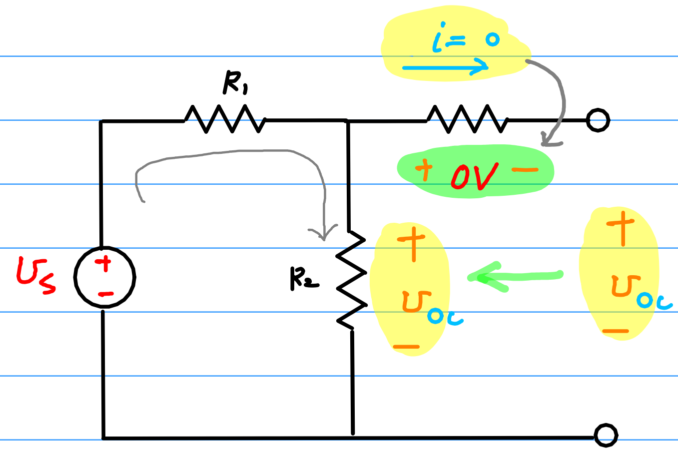


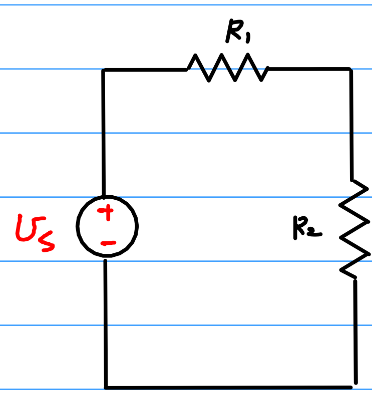


1. remove R_L → OC
2. v_{oc}



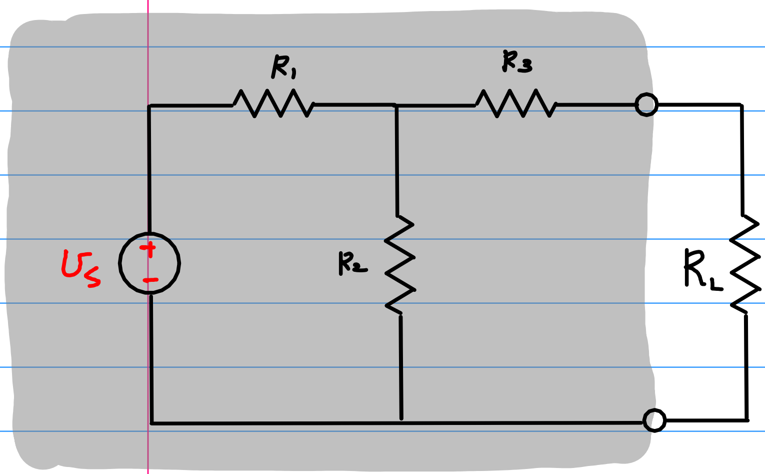






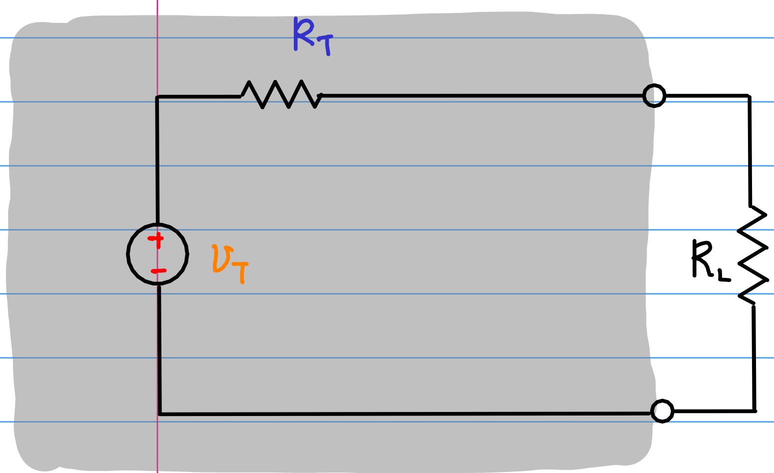
$$U_{oc} = \frac{R_2}{R_1 + R_2} U_s$$

$\Rightarrow V_T$



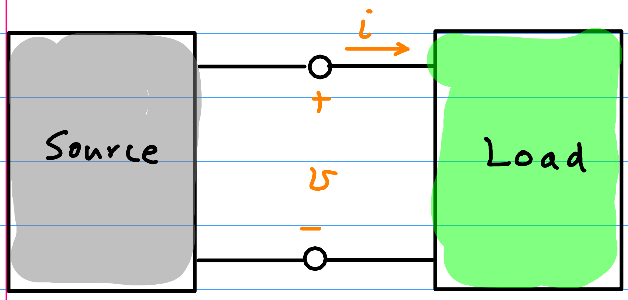
$$R_T = R_1 \parallel R_2 + R_3$$

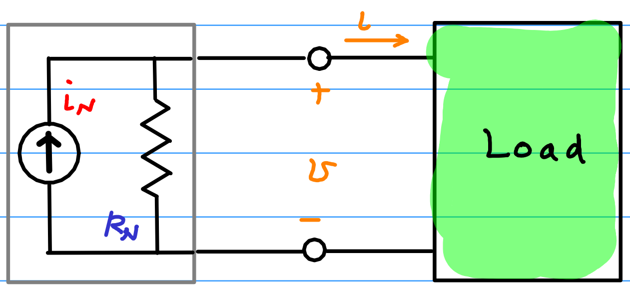
$$v_T = \frac{R_2}{R_1 + R_2} v_S$$

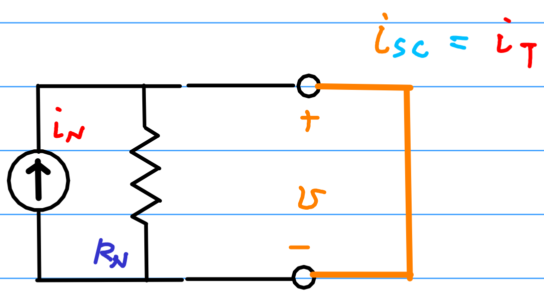


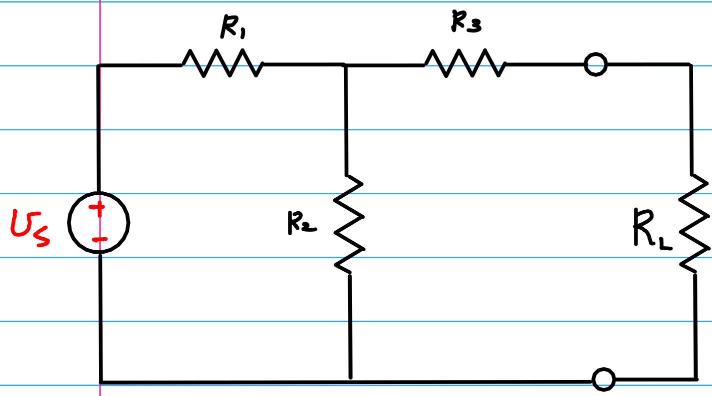
Norton Current i_T

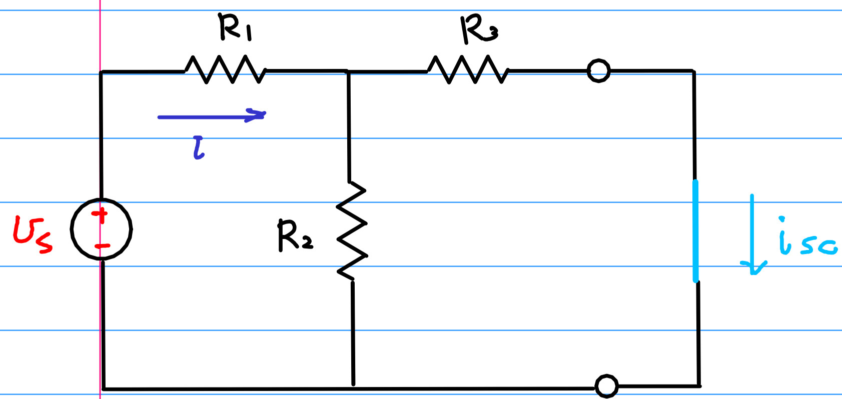
$\boxed{\text{max } i}$



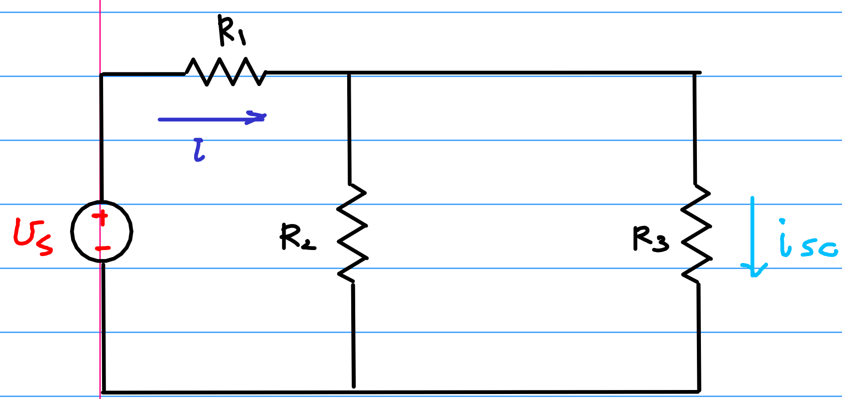








$$i = \boxed{\frac{U_s}{R_1 + R_2 \| R_3}}$$



$$i_{sc} = \boxed{\frac{U_s}{R_1 + R_2 \| R_3}} \frac{R_2}{R_2 + R_3}$$

$$\Rightarrow i_N$$

$$i = \boxed{\frac{U_s}{R_1 + R_2 \| R_3}}$$

$$i_{sc} = \boxed{\frac{U_s}{R_1 + R_2 \| R_3}} \frac{R_2}{R_2 + R_3}$$

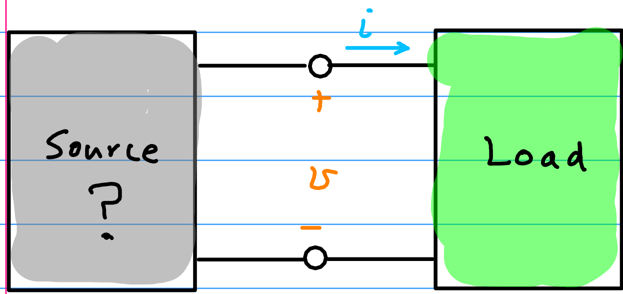
$\Rightarrow i_N$

$$R_2 \| R_3 = \frac{1}{\frac{1}{R_2} + \frac{1}{R_3}} = \frac{R_2 R_3}{R_2 + R_3}$$

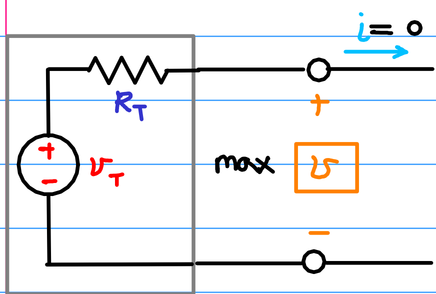
$$(R_1 + R_2 \| R_3)(R_2 + R_3) = R_1 (R_2 + R_3) + R_2 R_3$$

$$\frac{R_2}{(R_1 + R_2 \| R_3)(R_2 + R_3)} = \frac{R_2}{(R_1 + R_3) R_2 + R_1 R_3}$$

$$i_N = \frac{R_2}{(R_1 + R_3) R_2 + R_1 R_3} U_s$$



Thévenin Voltage v_T

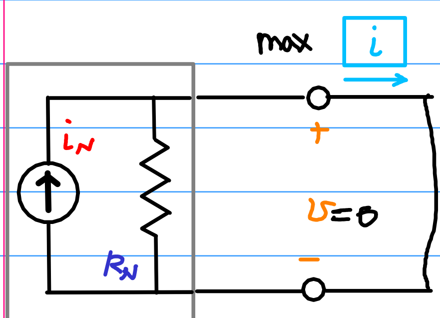


$v_T = v_{oc}$ when $i = 0$

$R_T = R_N$

$\boxed{\text{max } v}$

Norton Current i_N



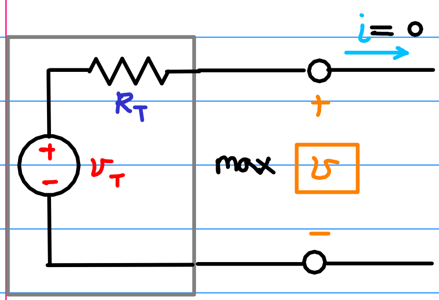
$i_N = i_{sc}$ when $v = 0$

$R_N = R_T$

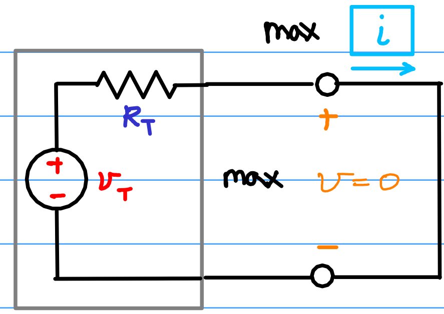
$\boxed{\text{max } i}$

$$\boxed{v_T = R_T \, i_N}$$

Thévenin Equivalent Circuit



OC

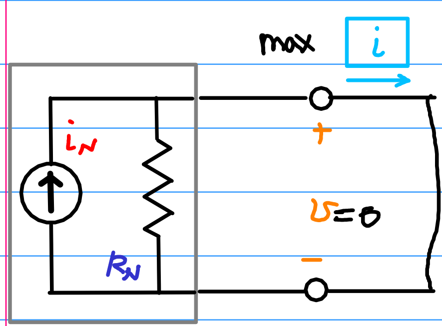


$i = \frac{v_T}{R_T}$

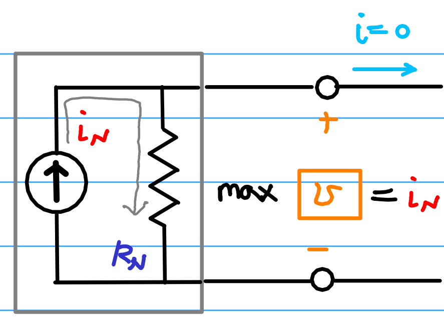
$= i_N$

SC

Norton Equivalent Circuit



SC

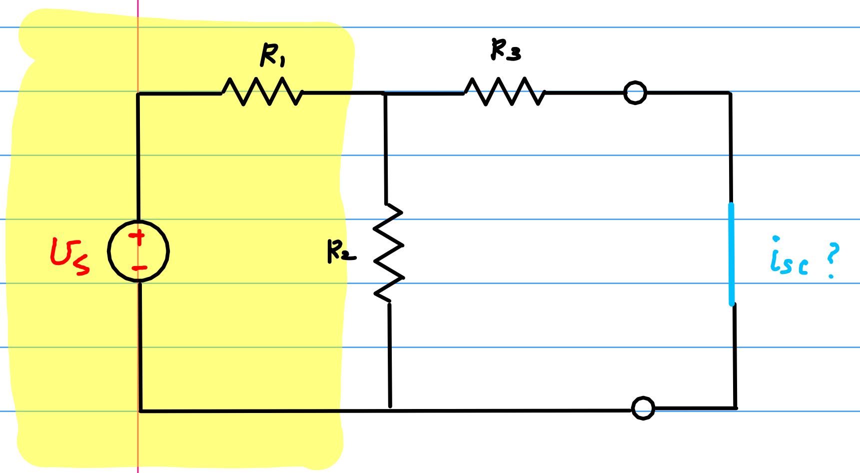


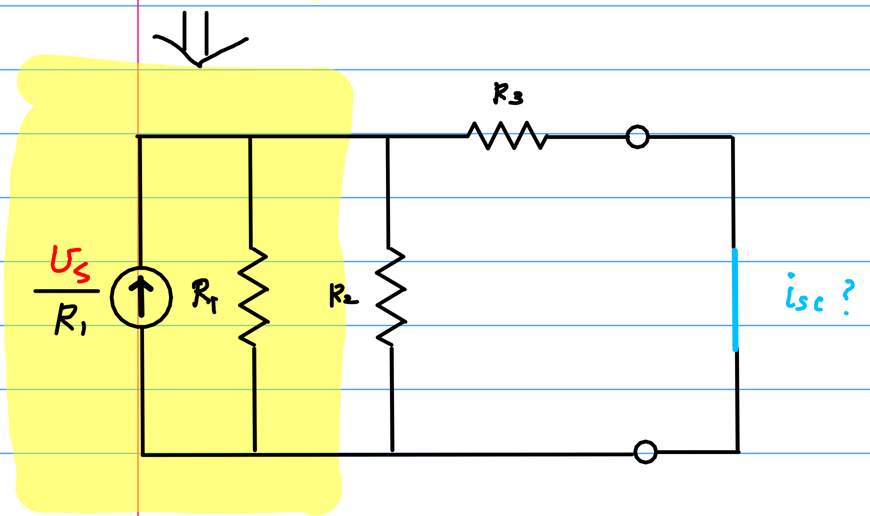
max $\boxed{v} = i_N R_N \Rightarrow v_T$

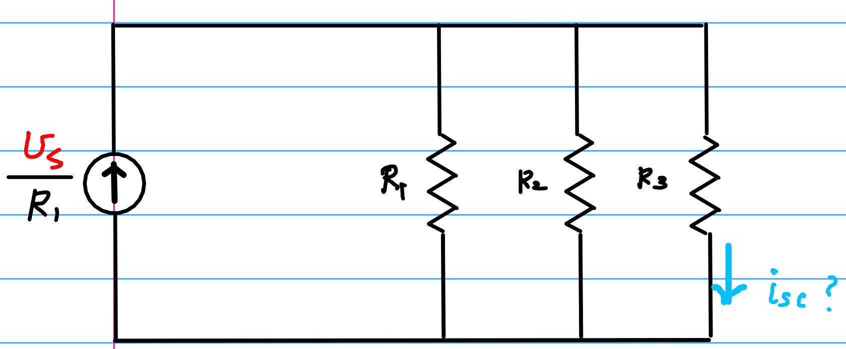
OC

$$\boxed{v_T = R_T i_N}$$

Source Transformation







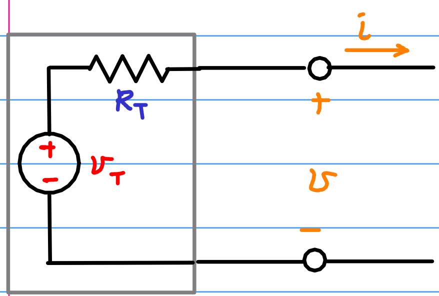
$$i_{sc} = \frac{1/R_3}{1/R_1 + 1/R_2 + 1/R_3} \frac{U_s}{R_1}$$

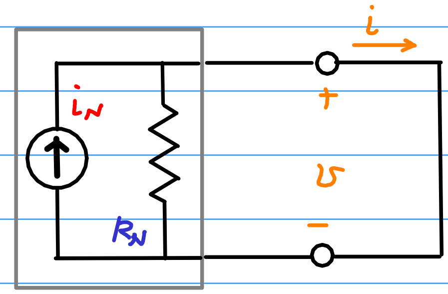
$$= \frac{\cancel{R_1} R_2}{R_2 R_3 + R_1 R_3 + R_1 R_2} \frac{1}{\cancel{R_1}} U_s$$

$$= \frac{R_2 U_s}{R_2 R_3 + R_1 R_3 + R_1 R_2}$$

Source Side Equation R_T

$\boxed{\max v} \leftarrow \boxed{R_L = \infty}$ $\boxed{\max i} \leftarrow \boxed{R_L = 0}$

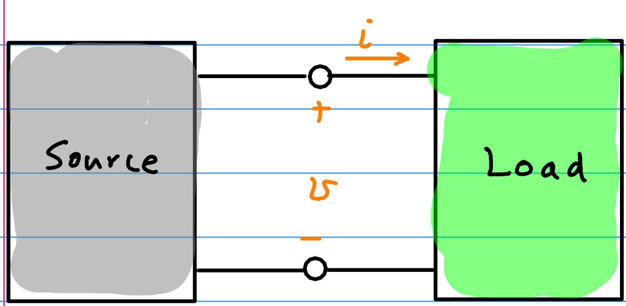


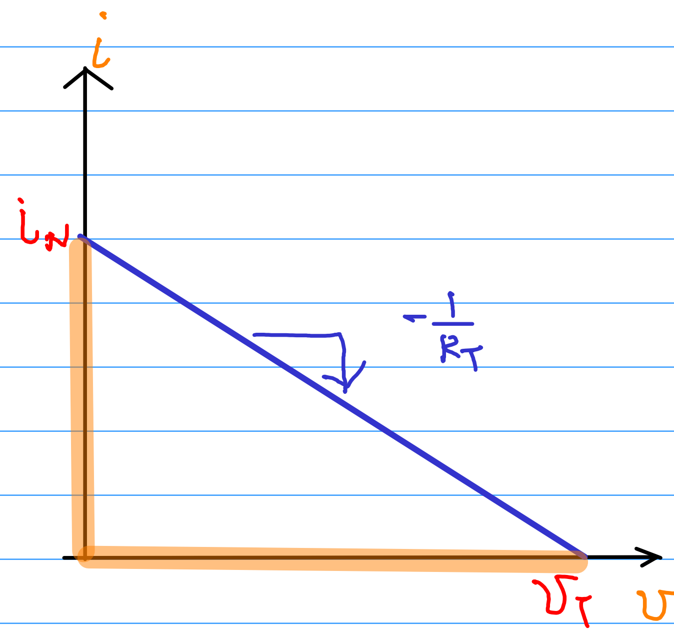


$\boxed{i < i_N}$

$\boxed{v < v_T}$

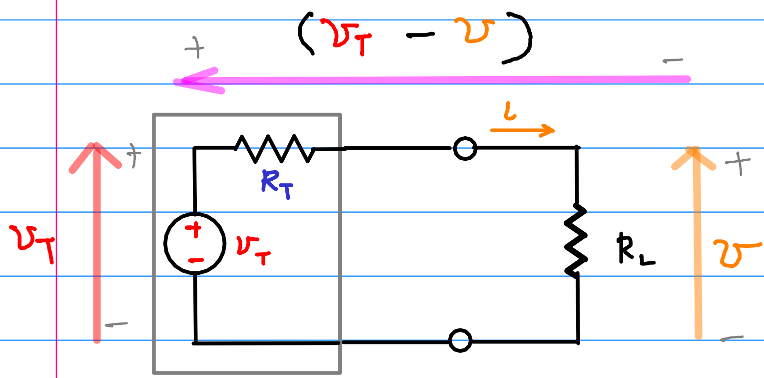
$\boxed{0 < R_L < \infty}$





$$i = \frac{1}{R_T}(v_T - v)$$

Load Line

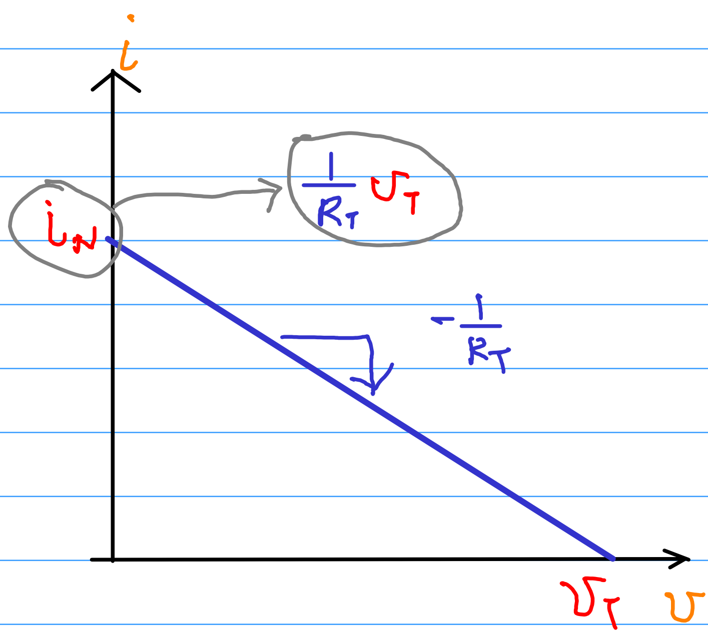


$$(v_T - v) = R_T \cdot i$$

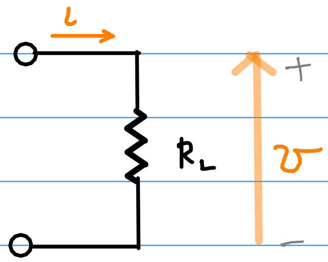
$$i = \frac{1}{R_T}(v_T - v) \qquad R_T = R_N$$

$$i = -\frac{1}{R_T} v + \frac{1}{R_T} v_T$$

$$y = -a x + b$$

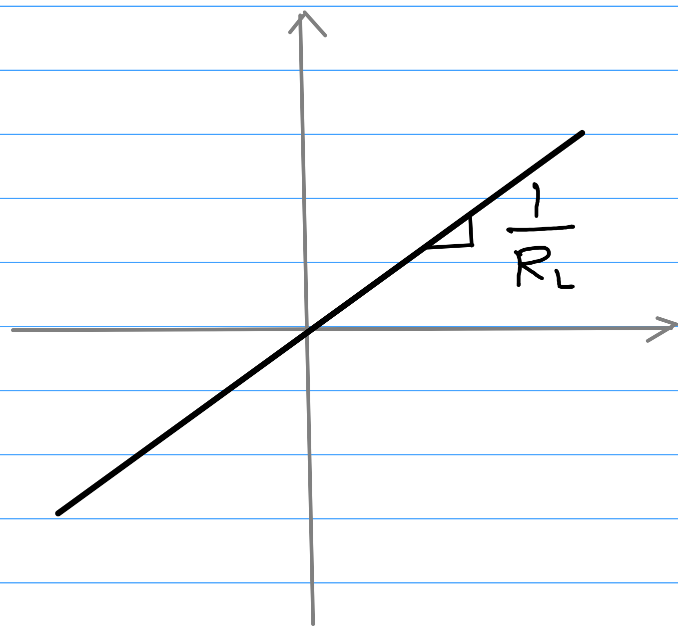


Load side Equation

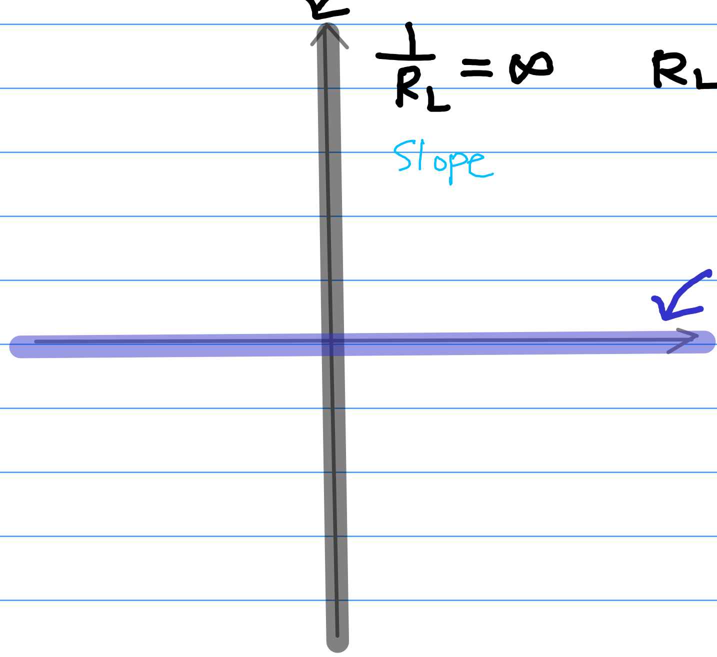


$$v = i R_L$$

$$i = \frac{1}{R_L} v$$



$$0 < R_L < \infty$$



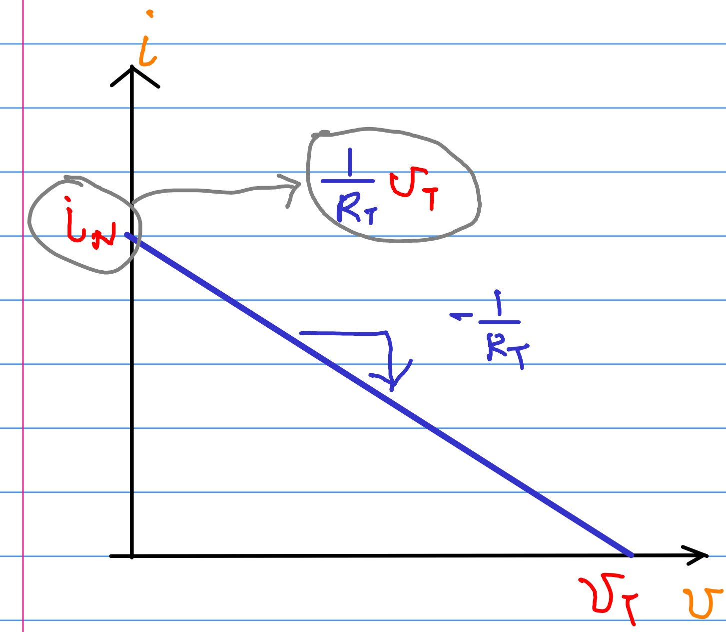
$\frac{1}{R_L} = \infty$ $R_L = 0$

slope

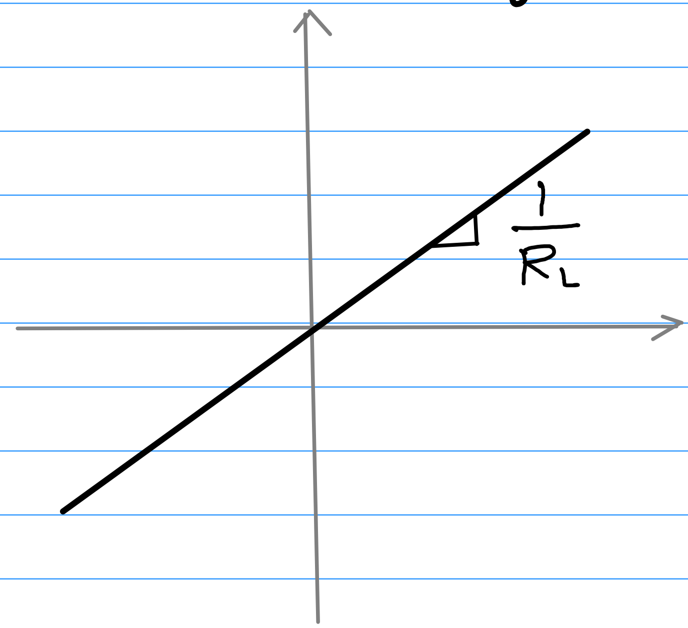
$\frac{1}{R_L} = 0$ $R_L = \infty$

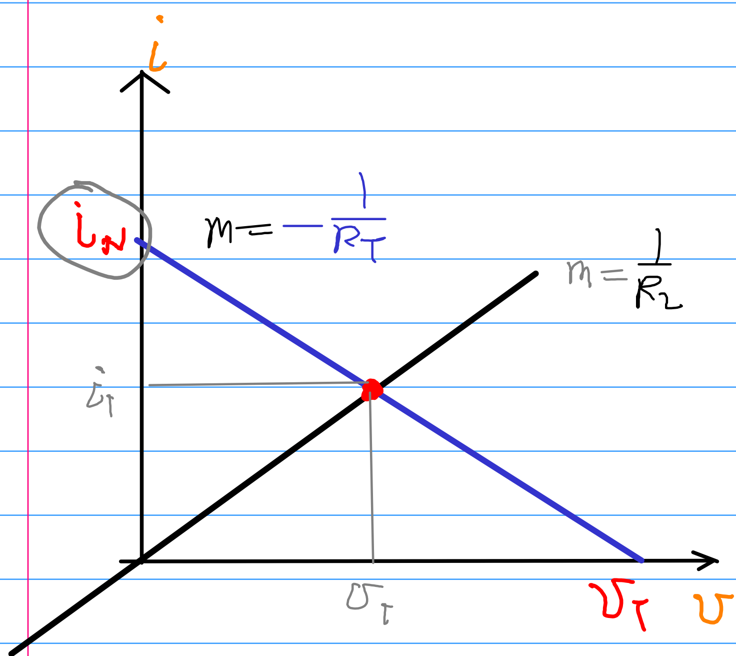
slope

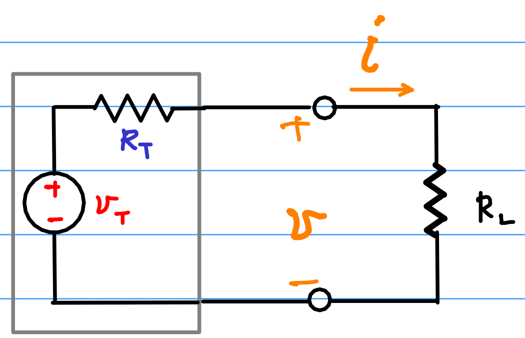
source side equation

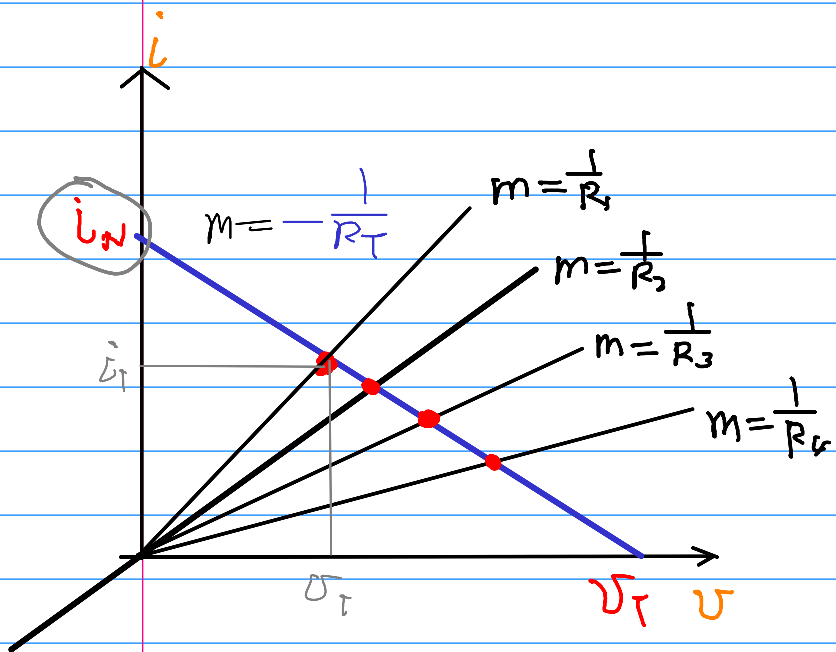


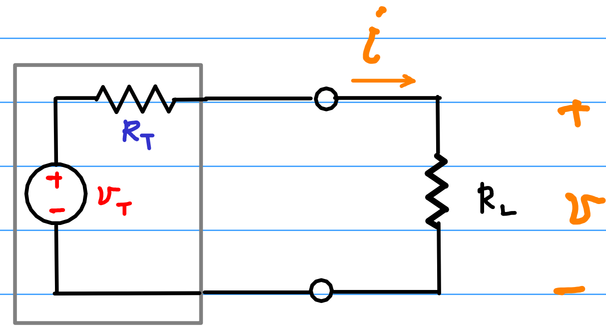
load side equation











$R_L = R_1 < R_2 < R_3$ .....

$i \downarrow \quad v \uparrow$