l1

EE16A Touchscreen Module - Lecture 4

* Superposition
* Equivalence

Goal: Want to design interesting systems
→ give insight.

<u>Reminder:</u> <u>Circuit analysis objective:</u>

Find $\vec{x} = \begin{bmatrix} I_1 \\ \vdots \\ I_m \\ U_1 \\ \vdots \\ U_k \end{bmatrix}$ for some ckt matrix A

$$A \cdot \vec{x} = \vec{b}$$

and $\vec{b} = \begin{bmatrix} I_{s1} \\ \vdots \\ I_{sl} \\ V_{sl+1} \\ \vdots \\ V_{s\,m+k} \end{bmatrix}$

$$\vec{x} = A^{-1} \vec{b}$$

$$\rightarrow \boxed{I_i} = \underbrace{\alpha_1 I_{s1}} + \cdots + \underbrace{\alpha_l I_{sl}} + \underbrace{\alpha_{l+1} V_{sl+1}} - - + \underbrace{\alpha_{m+k} V_{s\,m+k}}$$

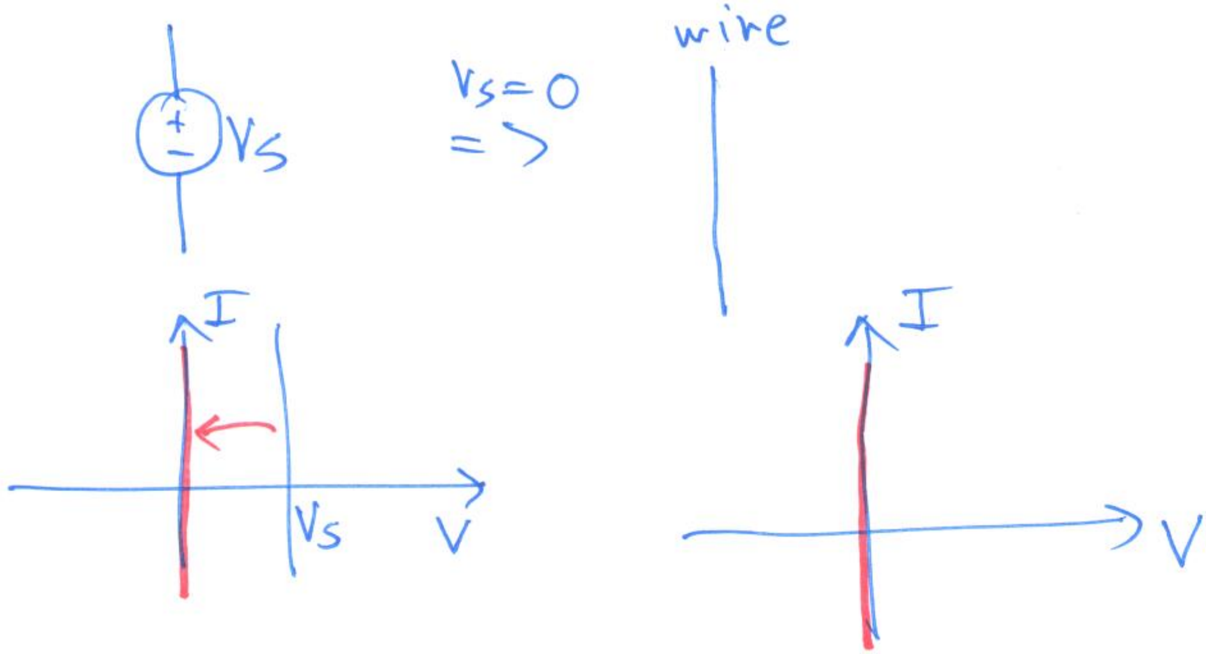
and

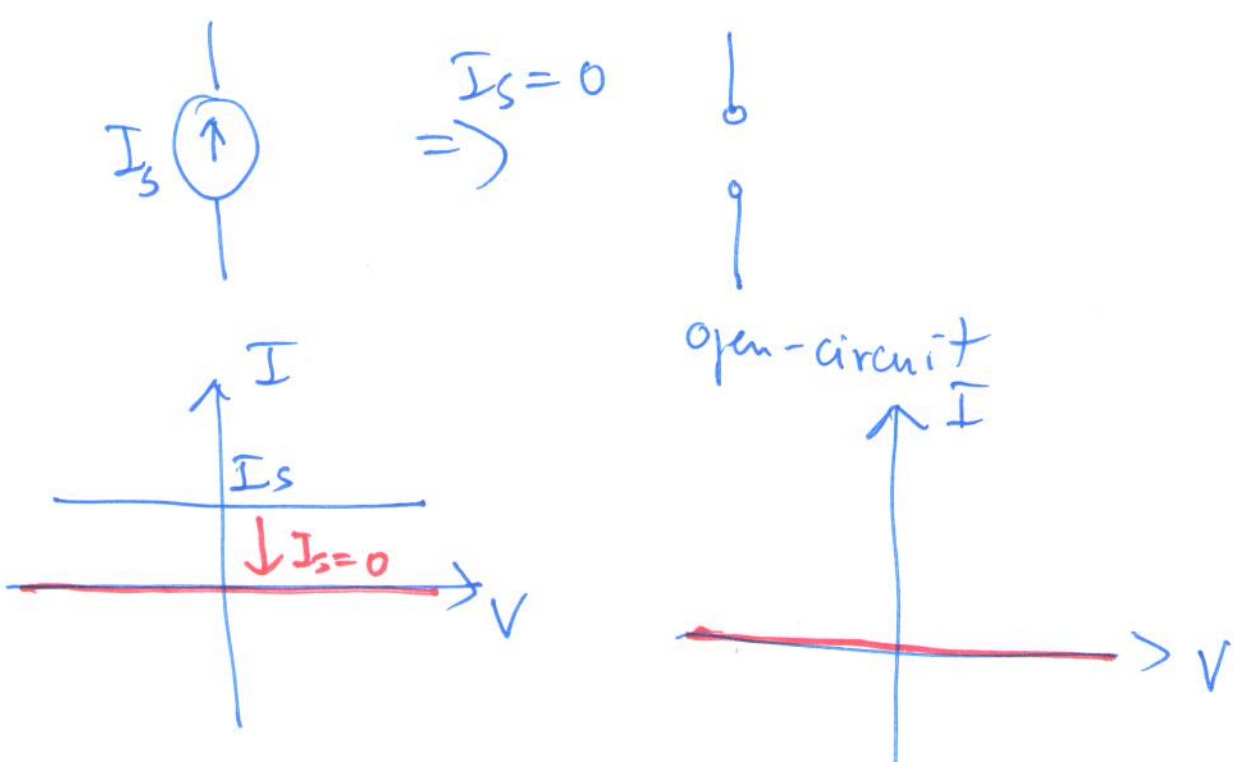
$$U_j = \beta_1 I_{s1} + \cdots + \underbrace{\beta_{m+k} V_{s\,m+k}}_{U_{j\,m+k}}$$

(12)

$$I_i = \underbrace{I_{i,1}}_{\alpha_1 I_{S1}} + \dots + \underbrace{I_{i,l}}_{\alpha_l I_{Sl}} + \underbrace{I_{i,l+1}}_{\alpha_{l+1} \cdot V_{S}} + \underbrace{I_{i,n}}_{\alpha_{l+k} \cdot V_{S}}$$

$I_{i,l+1}$

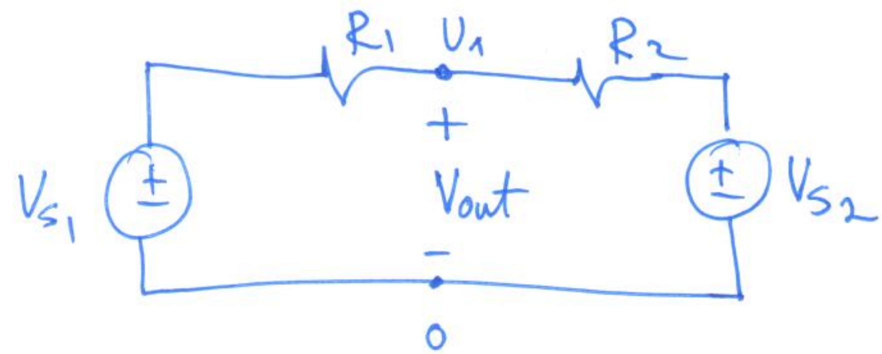




(3)

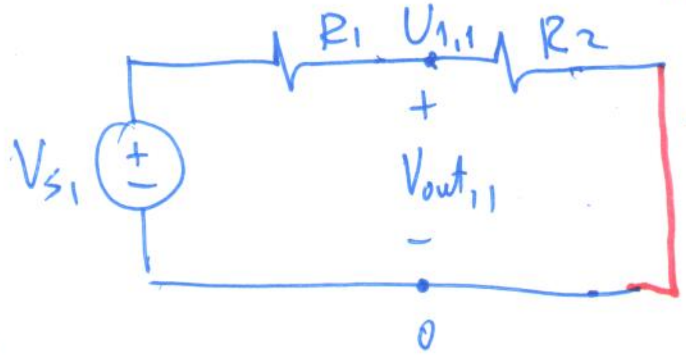
Superposition: Find I's and U's by turning on one source at a time and solving the ckt.

Example: voltage summer



$U_1 = V_{out}$

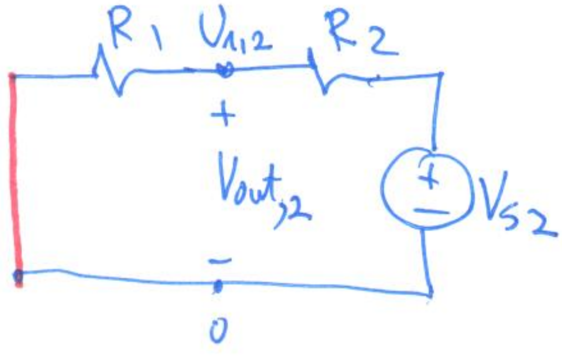
step 1: Compute a response to $V_{s1} \Rightarrow V_{s2} = 0$



(voltage divider)

$$\boxed{V_{out_{1,1}} = \frac{R_2}{R_1 + R_2} V_{s1}}$$

step 2: Compute a response to $V_{s2} \Rightarrow V_{s_1} = 0$



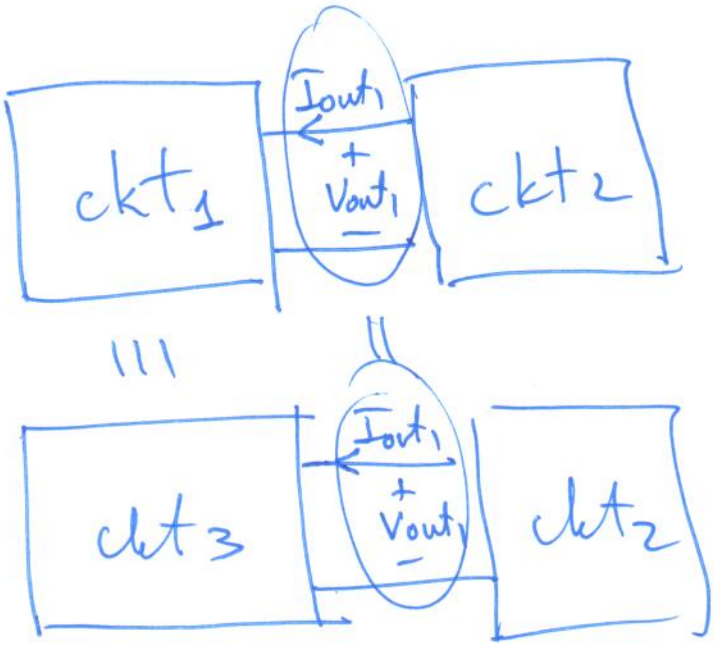
voltage divider

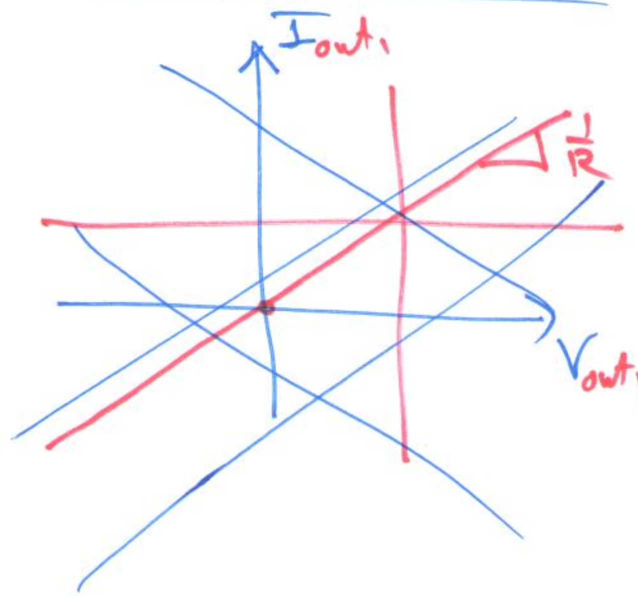
$$\boxed{V_{out,2} = \frac{R_1}{R_1 + R_2} \cdot V_{s2}}$$

$$V_{out} = V_{out,1} + V_{out,2} = \underbrace{\frac{R_2}{R_1+R_2}}_{\alpha} V_{S1} + \underbrace{\frac{R_1}{R_1+R_2}}_{\beta} V_{S2}$$

$$\frac{1}{1+\frac{R_1}{R_2}} \qquad \frac{1}{1+\frac{R_2}{R_1}}$$

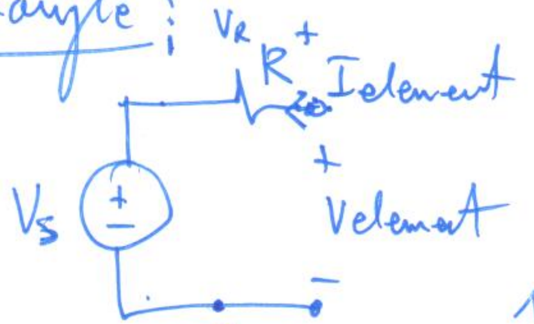
* Equivalence





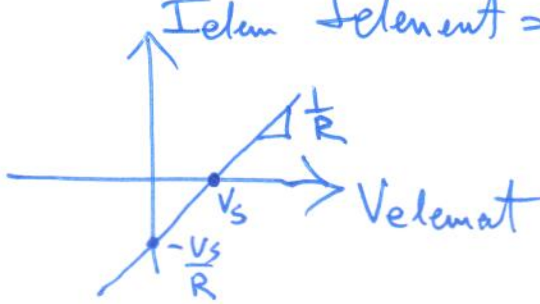
In ckts, two elements (ckts) are equivalent if they have the same I-V characteristic.

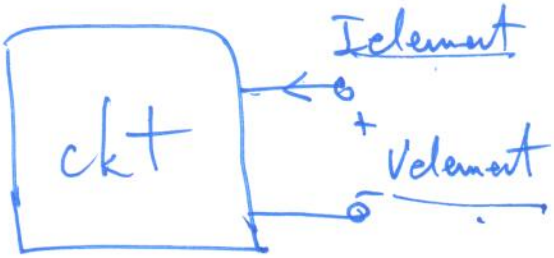
example:



$$\overbrace{I_{element} \cdot R}^{V_R} + V_S = V_{element}$$

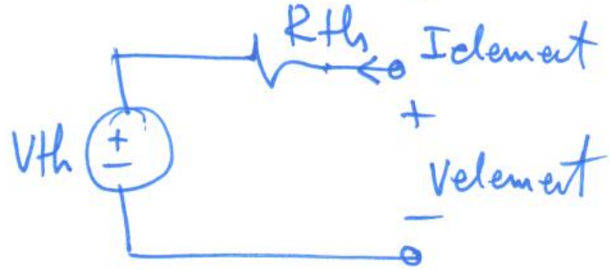
$$I_{element} = \frac{1}{R} V_{element} \underbrace{- \frac{V_S}{R}}$$



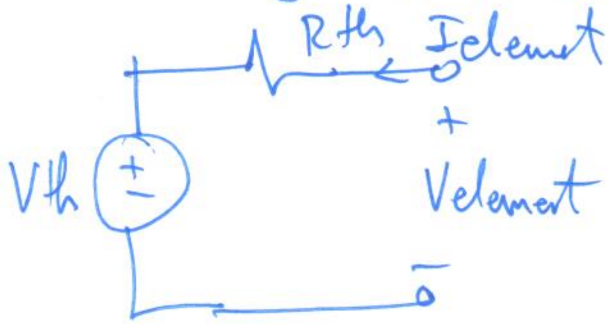


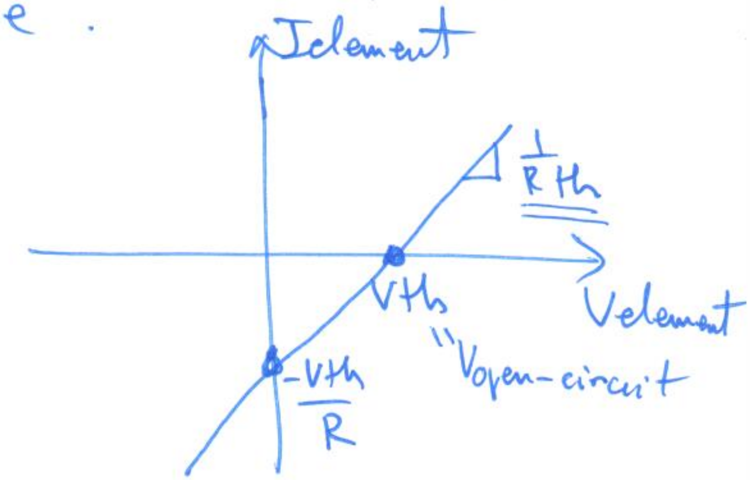
$\equiv$

Thevenin-equivalent



Need min of two elements (a resistor and a source) to create any I-V line.

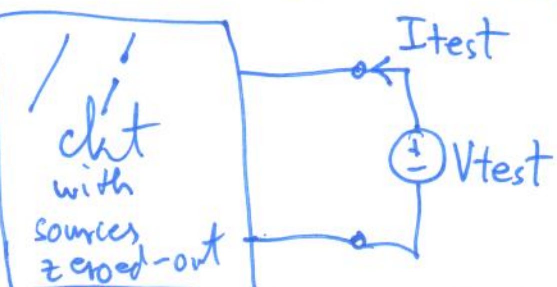




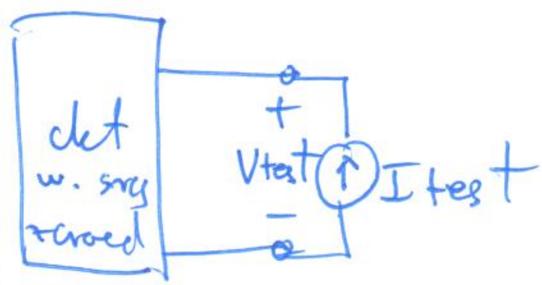
To find Vth: "Connect" an "open-circuit" across two terminals and measure

$V_{open\text{-}ckt} = V_{th}$

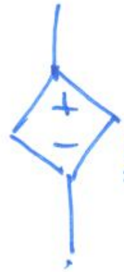
To find Rth: Zero-out any <u>independent</u> sources (to find a slope)



or



$$R_{th} = \frac{V_{test}}{I_{test}}$$


$\underline{\underline{\alpha}} V_i$ [V]

voltage-controlled voltage source

$\boxed{\text{det } \overset{+}{\underset{-}{V_i}}}$

VCVS


αI_j

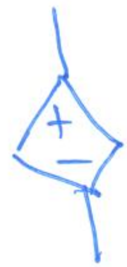
current-controlled current source

CCCS

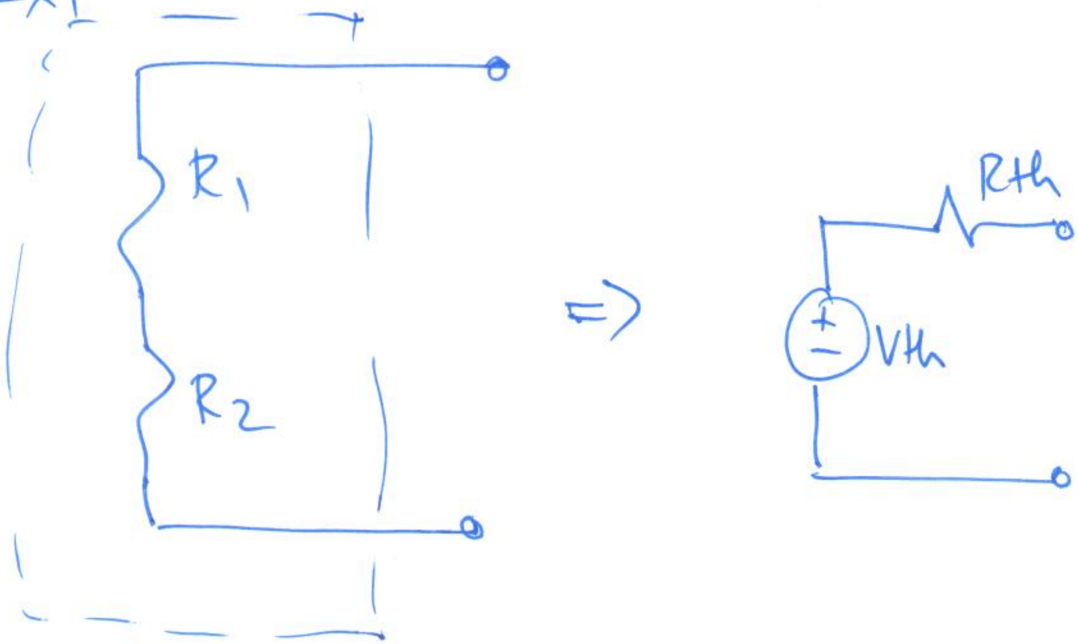

$g \cdot V_k$

VCCS

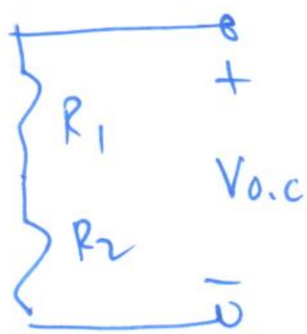
CCVS


$r \cdot I_j$

(p7) Ex 1

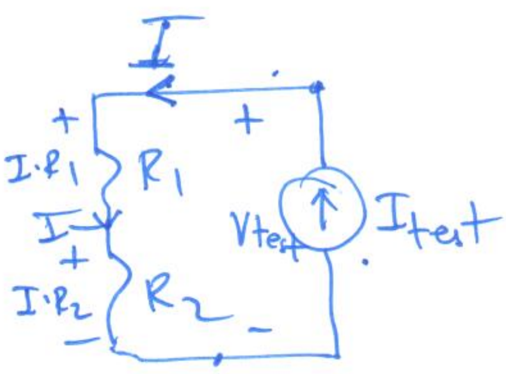


step 1:



$V_{o.c} = 0 \Rightarrow V_{th} = 0$

step 2: No sources =>

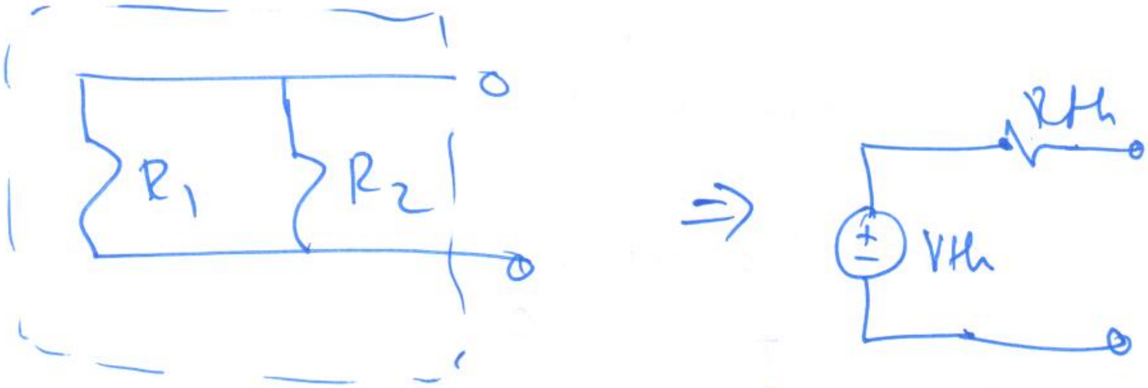


$$V_{test} = I_{test}(R_1 + R_2)$$

$$= \underbrace{I}_{I_{test}} \cdot R_1 + \underbrace{I}_{I_{test}} \cdot R_2 = \underline{I_{test} \cdot (R_1 + R_2)}$$

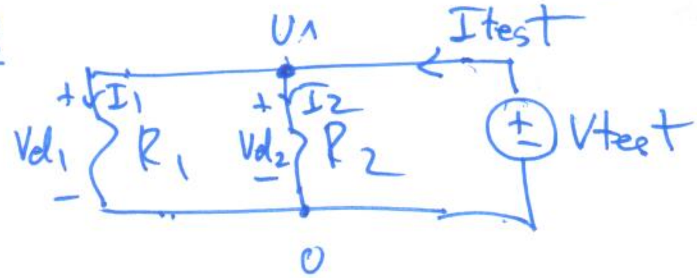
$$R_{th} = \frac{V_{test}}{I_{test}} = \underline{R_1 + R_2}$$

"in series" means that the same current flows through the elements



step 1: $V_{th} = 0$

step 2:



$U_1 = V_{test}$

$$Vel_1 = U_1 \Rightarrow I_1 = \frac{U_1}{R_1}$$

$$Vel_2 = U_1 \Rightarrow I_2 = \frac{U_1}{R_2}$$

$$I_{test} = I_1 + I_2 = \frac{V_{test}}{R_1} + \frac{V_{test}}{R_2}$$

$$= V_{test}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$= V_{test}\left(\frac{R_2 + R_1}{R_1 R_2}\right)$$

$$R_{th} = \frac{V_{test}}{I_{test}} = \frac{R_1 R_2}{R_1 + R_2} = \underbrace{R_1 \| R_2}_{\text{parallel operator}}$$

"in parallel" means voltage across them is the same.