(l1)

EE16A

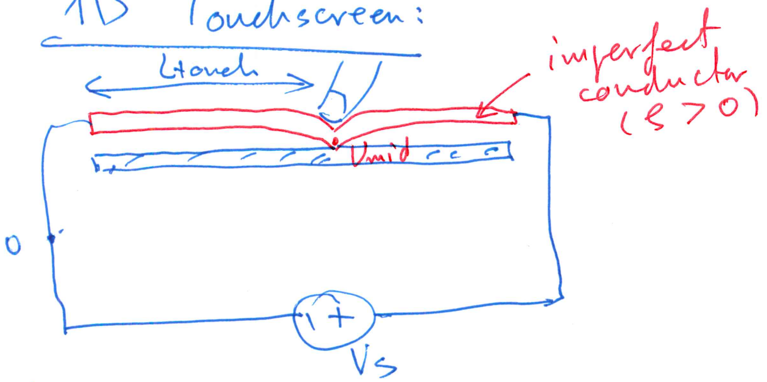
Lecture 3 - Module 2

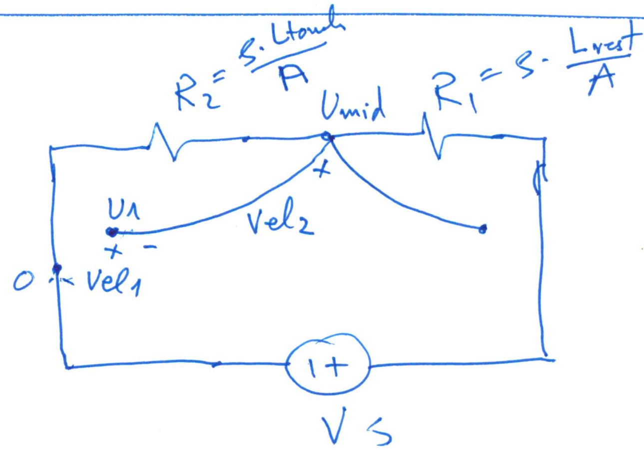
Today:

Note 13 & part of Note 14

* 1D Touchscreen wrap-up
* Measuring voltage & current
* Power
* An interesting ckt (start)

1D Touchscreen:





Model 0: $U_{mid} - 0 = U_{mid} = \frac{R_2}{R_1 + R_2} \cdot V_s = \frac{L_{touch}}{L} \cdot V_s$

Model 1: [hatched backplane] = ideal wire

el 1: open-circuit

el 2: wire

el 1: $V_{el1} = U_1 - 0$ (def. of elem. voltage) (1)

el 2: $\underline{V_{el2}} = U_{mid} - U_1$ (def. of elem voltage) (2)

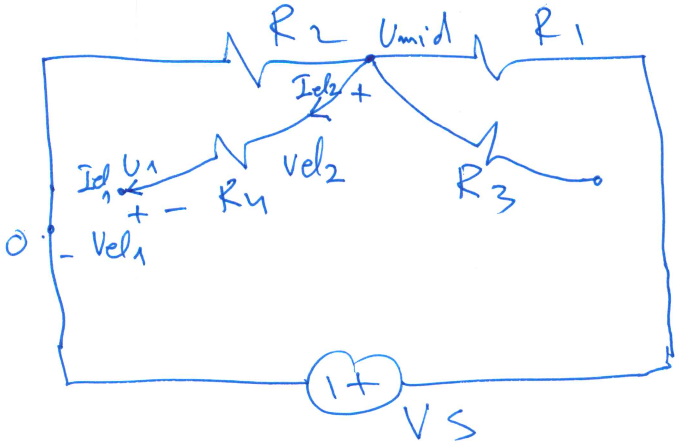
(1) $U_1 = V_{el1}$

(3) $V_{el2} = \underline{\underline{0}}$ (elem. definition)

$U_{mid} - U_1 = 0 \Rightarrow U_{mid} - V_{el1} = 0 \Rightarrow \boxed{V_{el1} = U_{mid}}$

Measure Umid at Vel1 regardless of the backplane conductor material & value of Ltouch.

(2) Model 2 :  imperfect conductor (resistor)



el1: open-circuit

el2: resistor

KCL : $I_{el_1} = I_{el_2}$

el1 def: $I_{el_1} = 0$

$\Downarrow$

$I_{el_2} = 0$

el2 def: $V_{el_2} = I_{el_2} \cdot R_4$

$V_{el_2} = 0$

(V_{el_2} def): $V_{el_2} = U_{mid} - U_1$

$U_{mid} - U_1 = 0$

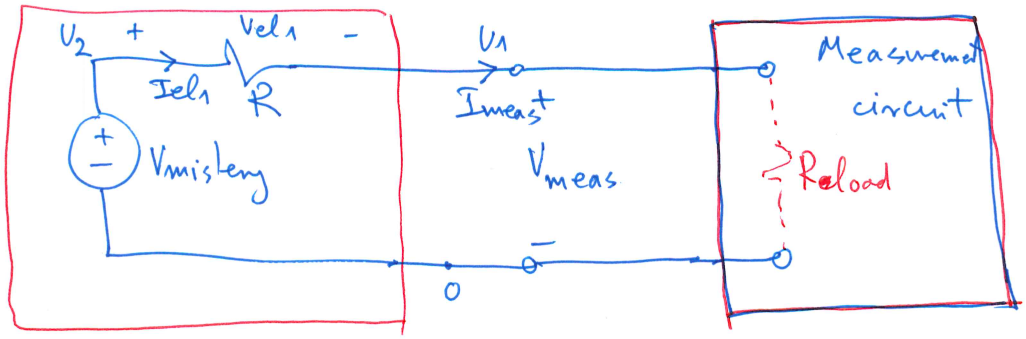
(V_{el_1} def): $V_{el_1} = U_1 - 0 = U_1$

$U_{mid} = U_1$

$$\boxed{V_{el_1} = U_{mid}}$$

Measure U_{mid} at V_{el_1} regardless of <u>backplane conductor material</u>.

l3



Want:

$V_{meas} = V_{mistery}$, $V_{el1} = I_{el1} \cdot R$ (elem. def)

$I_{el1} = I_{meas}$ (KCL)

$V_{mistery} = U_2 - 0$ (voltage def)

$V_{meas} = U_1 - 0$ (voltage def)

$\Rightarrow V_{el1} = U_2 - U_1$ (voltage def)

$\Rightarrow I_{el1} \cdot R = V_{mistery} - V_{meas}$

$I_{meas} \cdot R = V_{mistery} - V_{meas}$

$$V_{meas} = V_{mistery} - I_{meas} \cdot R$$

$I_{meas} = \frac{V_{meas}}{R_{load}}$

when $I_{meas} = 0 \Rightarrow V_{meas} = V_{mistery}$.

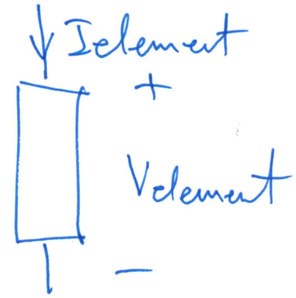
Measurement should <u>not</u> change the energy of the circuit (cause energy dissipation)

Define a voltage between points A & B as:

$V_{AB} = \frac{dE_{AB}}{dq}$ dE_{AB} - energy needed to move a particle dq from B to A

Power: (rate of energy change): $P = \frac{dE}{dt} = \underbrace{\frac{dE}{dq}}_{V} \cdot \underbrace{\frac{dq}{dt}}_{I} = V \cdot I$

passive-sign convention:



$$P_{element} = \underbrace{V_{element}} \cdot I_{element} \quad \text{(def)}$$

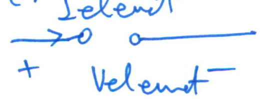
$$= I_{element} \cdot R \cdot I_{element} = R \cdot I_{element}^2 \geq 0$$

if element is a resistor

$V_{element} = I_{element} \cdot R$

$$= V_{element} \cdot \frac{V_{element}}{R} = \frac{V_{element}^2}{R} \geq 0$$

o.c.



$$P_{element} = V_{element} \cdot \cancelto{0 \text{ (def o.c.)}}{I_{element}} = 0$$

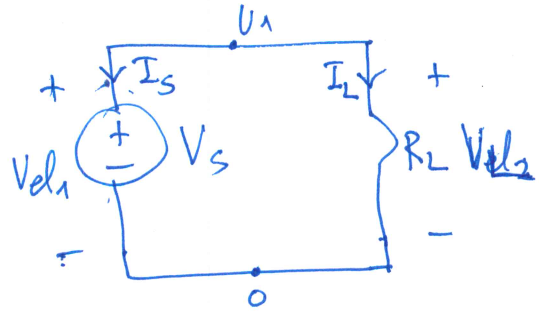
wire:

$$P_{element} = \cancelto{0 \text{ (def wire)}}{V_{element}} \cdot I_{element} = 0$$

Units : Power [W] = [V]·[A]

(5)

Example:



(KCL): $I_s = -I_L$

$$Vel_1 = U_1 - 0$$
$$V_L = U_1 - 0 \Rightarrow Vel_1 = V_L$$

$$P_s = Vel_1 \cdot I_s$$
$$= V_s \cdot I_s \quad \text{(el. df source)}$$

$$\underline{P_s = V_s \cdot I_s}$$

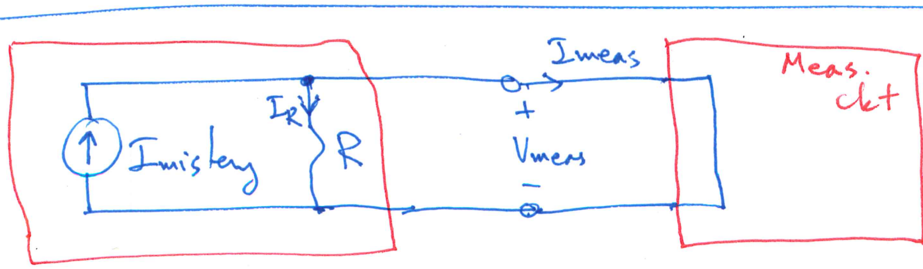
$$P_L = V_L \cdot I_L \quad \text{(def)}$$
$$= V_L \cdot (-I_s)$$
$$= Vel_1 \cdot (-I_s)$$
$$= V_s \cdot (-I_s) \quad \text{(def source)}$$
$$\Downarrow$$
$$\underline{P_L = -V_s \cdot I_s}$$

$$\underline{P_s = -P_L}$$

$P_L \geq 0$ b/c of $\underline{R_L}$

$P_s \leq 0$

$$\boxed{P_L + P_s = 0}$$ Conservation of energy (power)



Task: Measure $\underline{I_{mistery}}$

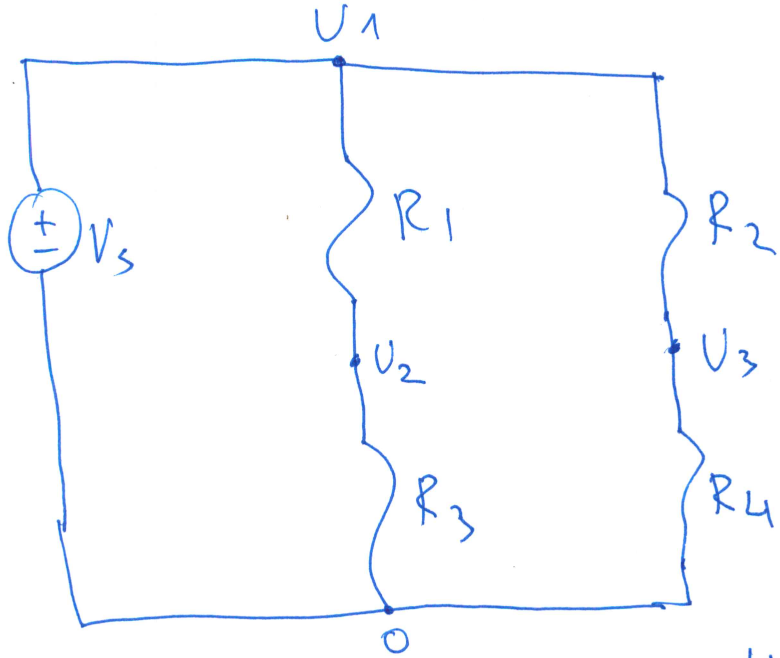
$I_{meas} = I_{mistery}$

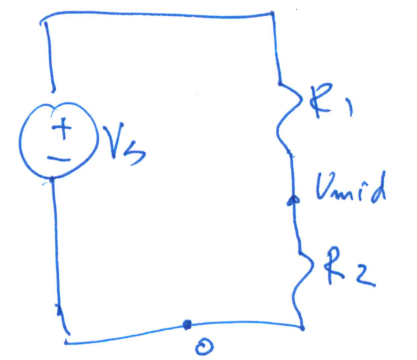
(KCL) $I_{mistery} = I_R + I_{meas}$ $\qquad V_{meas} = I_R \cdot R$

$P_{meas} = \overset{\to 0}{V_{meas}} \cdot I_{meas} = 0$ $\qquad I_{mistery} = \frac{V_{meas}}{R} + I_{meas}$

wire $\Rightarrow$ $V_{meas} = 0$ (def) $\Rightarrow \boxed{I_{mistery} = I_{meas}}$

An interesting circuit:





$$U_{mid} = \frac{R_2}{R_1+R_2} V_s$$

valtage - divider

What are U_2 & U_3?

$$U_2 = \frac{R_3}{R_1+R_3} V_s \qquad U_3 = \frac{R_4}{R_2+R_4} \cdot V_s$$

$$V_s = U_1 - 0 \quad (\text{def})$$

$$\cancel{U_2 - 0}^{\,U_2} = \frac{R_3}{R_1+R_3} \cdot \cancel{(U_1 - 0)}^{\,V_s} \quad (\text{v. div})$$

$$\cancel{U_3 - 0}^{\,U_3} = \frac{R_4}{R_2+R_4} \cdot \cancel{(U_1 - 0)}^{\,V_s} \quad (\text{v. div})$$