(L1)

EE16A

Lecture 2 – Module 2

Touchscreen intro – modeling with circuit elements

Today:
- Review ckt analysis (voltage divider example)
- Touchscreen construction
- Modeling
- Analysis + Modeling to design a touchscreen

Note 12 (reading)

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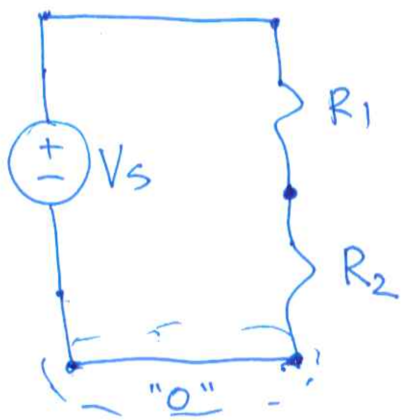
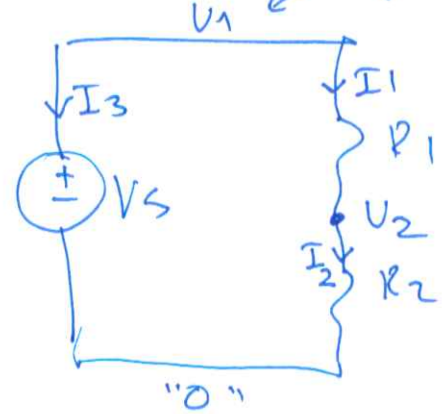
(2)

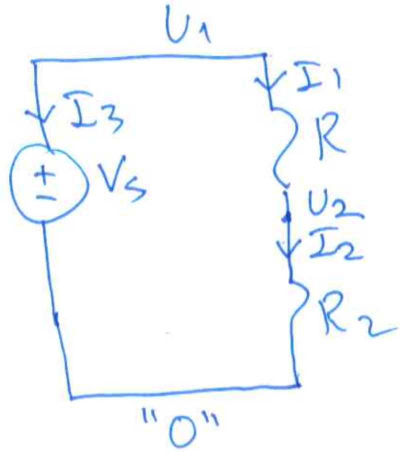


step 1 → label a "ref node"

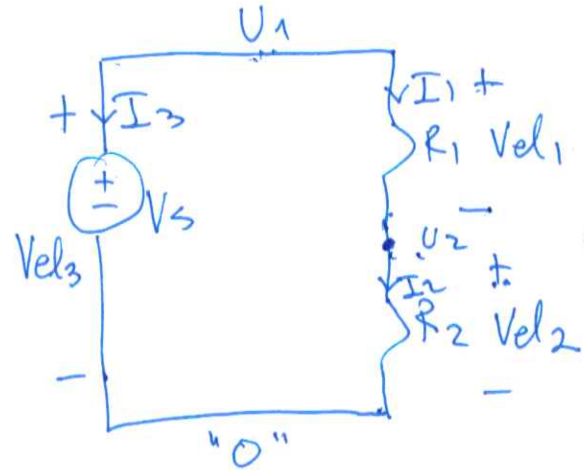
step 2 (label the potentials)



step 3 →



"tricky" step 4 →



step 5 →

step 5 → identify the unknowns

$$\vec{x} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ U_1 \\ U_2 \end{bmatrix}$$

step 6 → KCL

$$I_1 + I_3 = 0 \quad (1)$$

$$I_1 = I_2 \Rightarrow -I_1 + I_2 = 0 \quad (2)$$

step 7 → element voltages

Voltage - potential def	element I-V
$Vel_1 = U_1 - U_2$	$Vel_1 = R_1 \cdot I_1$
$Vel_2 = U_2 - 0 = U_2$	$Vel_2 = R_2 I_2$
$Vel_3 = U_1 - 0 = U_1$	$Vel_3 = V_s$

U_A (+), U_B (−): $V_{AB} = V_e = U_A - U_B$

$$R_1 I_1 = U_1 - U_2 \Rightarrow R_1 I_1 - U_1 + U_2 = 0 \quad (3)$$

$$U_2 = R_2 I_2 \Rightarrow R_2 I_2 - U_2 = 0 \quad (4)$$

$$U_1 = V_s \quad (5)$$

(3)

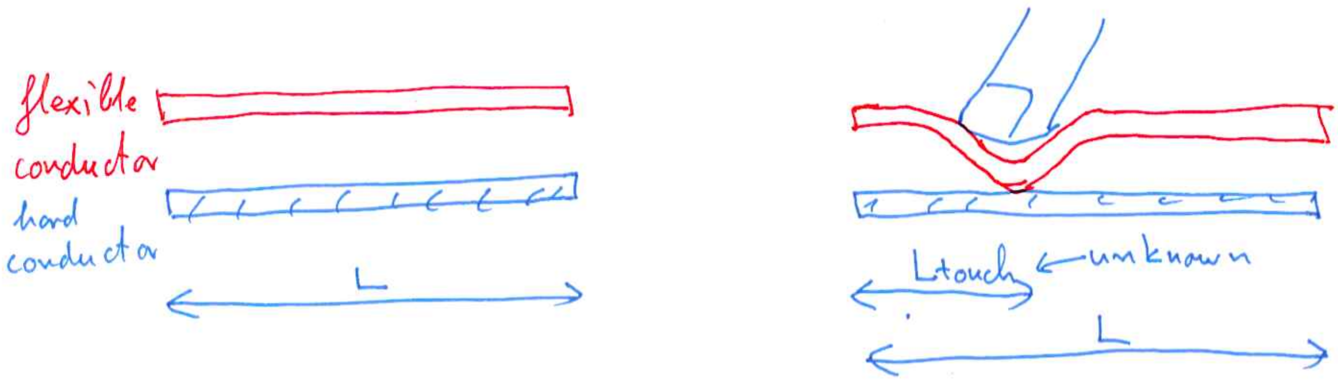
$$\begin{bmatrix} 1 & 0 & 1 & 0 & 0 \\ -1 & 1 & 0 & 0 & 0 \\ R_1 & 0 & 0 & -1 & 1 \\ 0 & R_2 & 0 & 0 & -1 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ U_1 \\ U_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ V_s \end{bmatrix}$$

$$I_1 = \frac{V_s}{R_1+R_2}, \quad I_2 = \frac{V_s}{R_1+R_2}, \quad I_3 = -\frac{V_s}{R_1+R_2}$$

$$U_1 = V_s, \quad \boxed{U_2 = \underbrace{\frac{R_2}{R_1+R_2}}_{\alpha < 1} \cdot V_s} = R_2 \cdot \underbrace{\frac{V_s}{R_1+R_2}}_{I_2}$$

voltage divider

Resistive touchscreen



Want to measure $\frac{L_{touch}}{L}$

Need to convert to electrical quantity.

16A Physics

* Charge - can be either positive or negative
basic element of electrical flow (e.g. electron)
Unit: Coulomb [C]

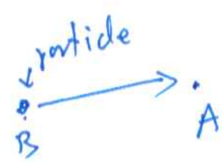
* Current - Net amount of charge that passes through some cross-section area over some period of time

$$[A] \rightarrow I = \frac{dQ}{dt} \quad \begin{matrix} \leftarrow [C] \\ \leftarrow [s] \end{matrix}$$

Always do unit checks

* Voltage - Represents the energy to move a positive unit of charge from one point to the other

V_{AB}

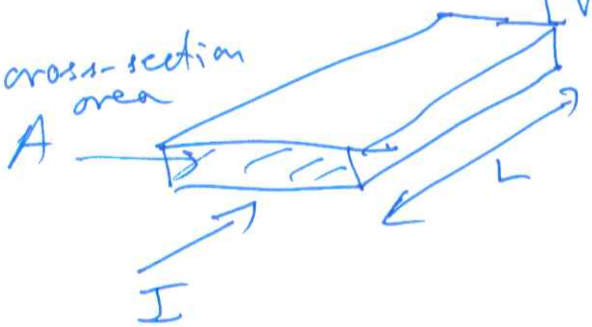


$$[V] = \frac{[J]}{[C]} \leftarrow \text{energy}$$

* Resistance – real pieces of metal always require a certain amount of energy to allow charge to flow through

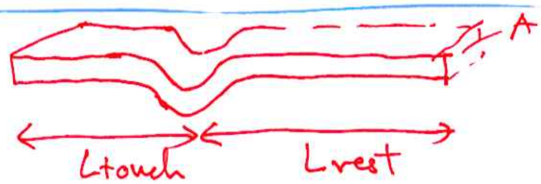
$$V = I \cdot R$$

$$[V] = [A] \cdot [\Omega]$$



$$R = \rho \cdot \frac{L}{A}$$

Physical:

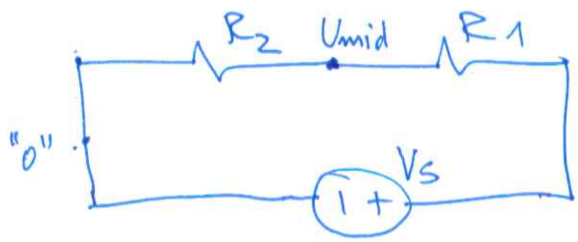


$$R_1 = \rho \cdot \frac{L_{rest}}{A} \quad (1)$$

Model:

$$R_2 = \rho \cdot \frac{L_{touch}}{A} \quad (2)$$

⇓ Build a circuit using this model to <u>measure</u> $\frac{L_{touch}}{L}$ as an <u>electrical</u> quantity.



$$U_{mid} = \frac{R_2}{R_2 + R_1} \cdot V_s \quad \text{(voltage divider)}$$

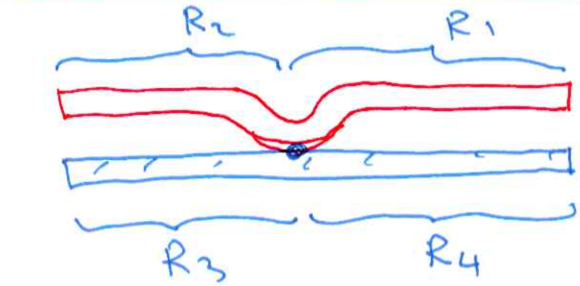
$$\overset{(1)\,\&\,(2)}{=} \frac{\rho \cdot \frac{L_{touch}}{A}}{\rho \cdot \frac{L_{touch}}{A} + \rho \cdot \frac{L_{rest}}{A}} V_s$$

$$= \frac{L_{touch}}{L_{touch} + L_{rest}} V_s = \frac{L_{touch}}{L} V_s$$

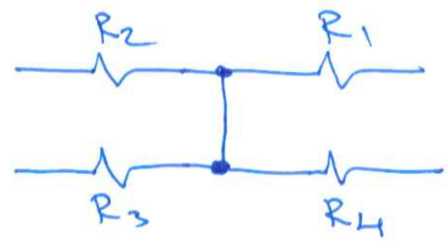
$$\boxed{U_{mid} = \frac{L_{touch}}{L} \cdot V_s}$$

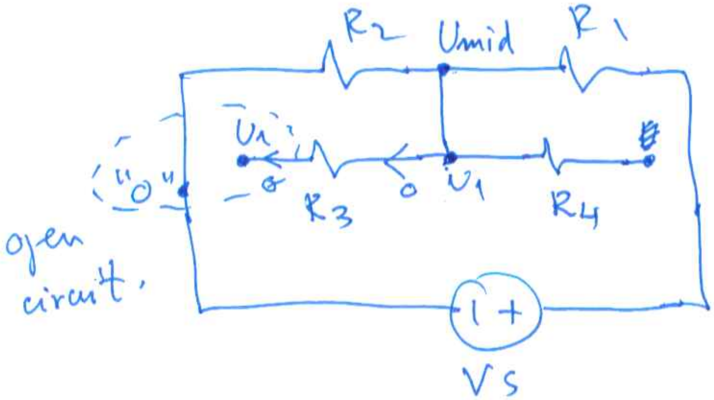
can always measure $\frac{L_{touch}}{L}$ regardless of the material type

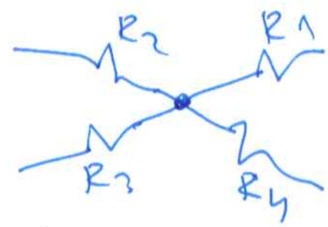
A more realistic model :



R_1, R_2, R_3 & R_4 are unknown







$U_1 = U_{mid}$