Module 2, Lecture 2

EECS 16A
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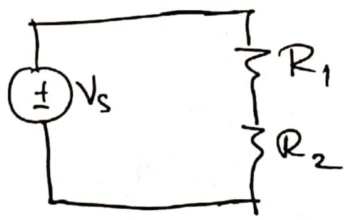
Last time:
- Key Elements I–V
- KCL, KVL
- Passive Sign Convention
- Intro to NVA

} Note 11

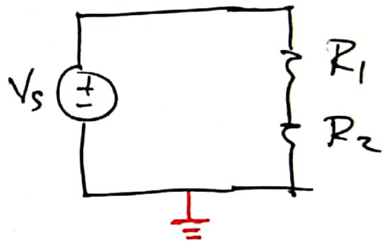
Today:
- Review NVA (voltage divider)
- Touchscreen Construction
- "16A" Physics
- Modeling
- Analysis & Modeling : Putting it All Together

} Note 12

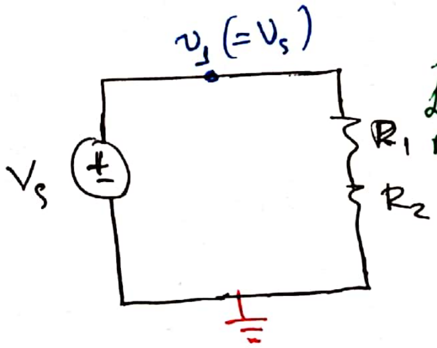
NVA Review : Voltage Divider



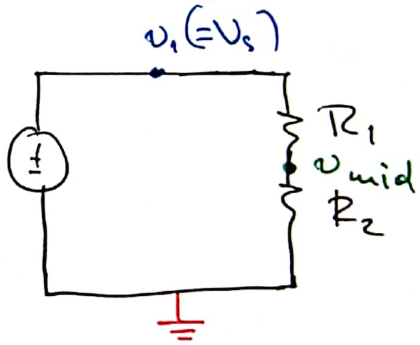
Step 1 → Pick and label a ground (⏚, 0)



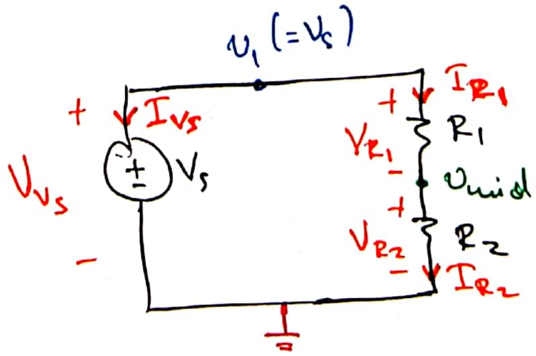
Step 2 → Label all nodes w/ voltages set by voltage sources



Step 3 → Label the remaining Vs nodes (unknown)



Step 4 → Label element current and voltages according to passive sign convention!



Step 5: KCL equation (only for unknown nodes)

$$I_{R_1} = I_{R_2}$$

Step 6: Element currents $\xrightarrow[\text{Law}]{\text{Ohm's}}$ element voltages + component characteristics

$$I_{R_1} = \frac{V_{R_1}}{R_1}$$

$$I_{R_2} = \frac{V_{R_2}}{R_2}$$

Step 7: Element voltages $\rightarrow$ node voltages

$$I_{R_1} = \frac{V_{R_1}}{R_1} = \frac{v_1 - v_{mid}}{R_1} = \frac{V_s - v_{mid}}{R_1}$$

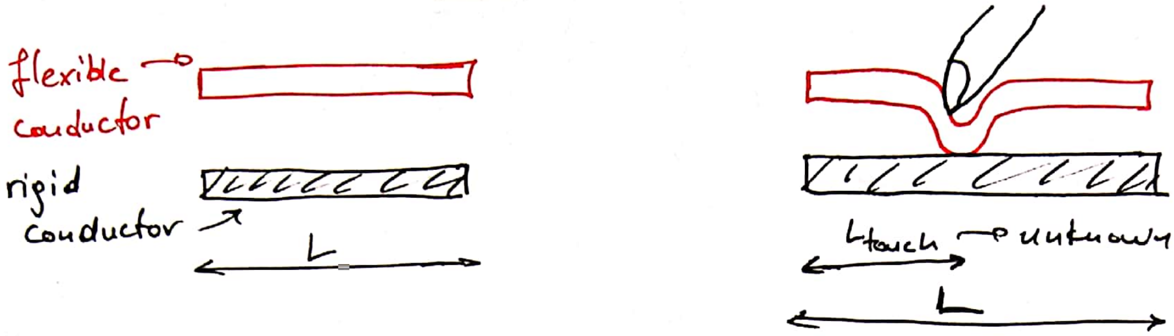
$$I_{R_2} = \frac{V_{R_2}}{R_2} = \frac{v_{mid} - 0}{R_2} = \frac{v_{mid}}{R_2}$$

Step 8: Substitute Step 7 $\rightarrow$ Step 5 and solve for the unknown node voltages.

$$I_{R_1} = I_{R_2} \Rightarrow \frac{V_s - v_{mid}}{R_1} = \frac{v_{mid}}{R_2} \Rightarrow$$

$$\boxed{v_{mid} = \frac{R_2}{R_1 + R_2} \cdot V_s}$$ Voltage divider

Resistive Touchscreen



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

Need to convert length (position) to an electrical quantity (V, I)

"JGA" Physics

* Charge – Can be either positive or negative
  Basic quantity of electrical flow (e.g. electron)
  Unit: Coulomb [C]

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

$$I = \frac{dQ}{dt}$$

[A] ← I, dQ → [C], dt → [s]

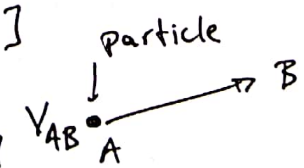
Always do unit checks!

$1C = 1A \cdot 1s$

* Voltage – Represents the energy spent to move a positive unit charge from one point A to another point B.

$$V = \frac{dE}{dq}$$

[V] ← V, dE → [J], dq → [C]

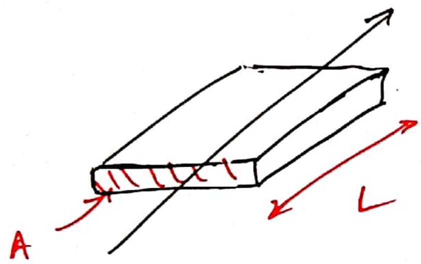


Resistance – Real pieces of metal require some amount of energy to allow charges to flow through them.

$V = I \cdot R$

$V \rightarrow [V]$, $I \rightarrow [A]$, $R \rightarrow [\Omega]$

Modeling a Resistor



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

$R \rightarrow [\Omega]$, $\rho \rightarrow [\Omega \cdot m]$, $L \rightarrow m$, $A \rightarrow m^2$

Resistance value depends on:

1) Geometry of the structure
2) Properties of the material

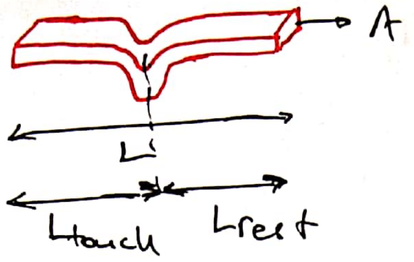
$\rho_{copper} = 1.7 \cdot 10^{-8}\ \Omega \cdot m$ → conductor

$\rho_{silicon} \simeq 6.4 \cdot 10^{2}\ \Omega \cdot m$ → semiconductor

$\rho_{quartz} \simeq 5 \cdot 10^{16}\ \Omega \cdot m$ → insulator

Resistive Touchscreen (Cont)

Physical:

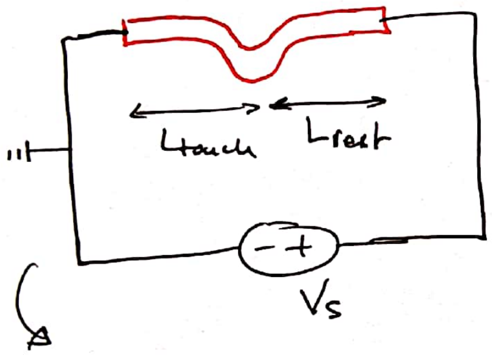


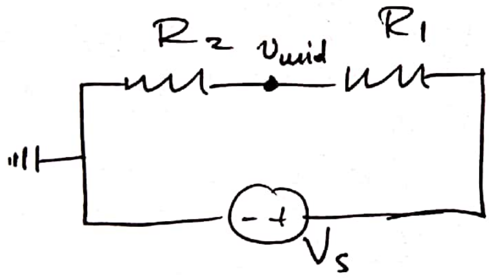
Model:

$$R_2 = \rho \cdot \frac{L_{touch}}{A}$$

$$R_1 = \rho \cdot \frac{L_{rest}}{A}$$

Goal Reminder: I want to build a ckt to measure $\frac{L_{touch}}{L}$ as an electrical quantity!





Voltage Divider:

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

$$= \frac{\rho \cdot \frac{L_{touch}}{A}}{\rho \cdot \frac{L_{rest}}{A} + \rho \cdot \frac{L_{touch}}{A}} \cdot V_s$$

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

$$= \frac{L_{touch}}{L} \cdot V_s$$

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

Can always measure $\frac{L_{touch}}{L}$ by measuring V_{mid} and knowing V_s.

Note: This is independent of the material type!

(p6)

More realistic Model