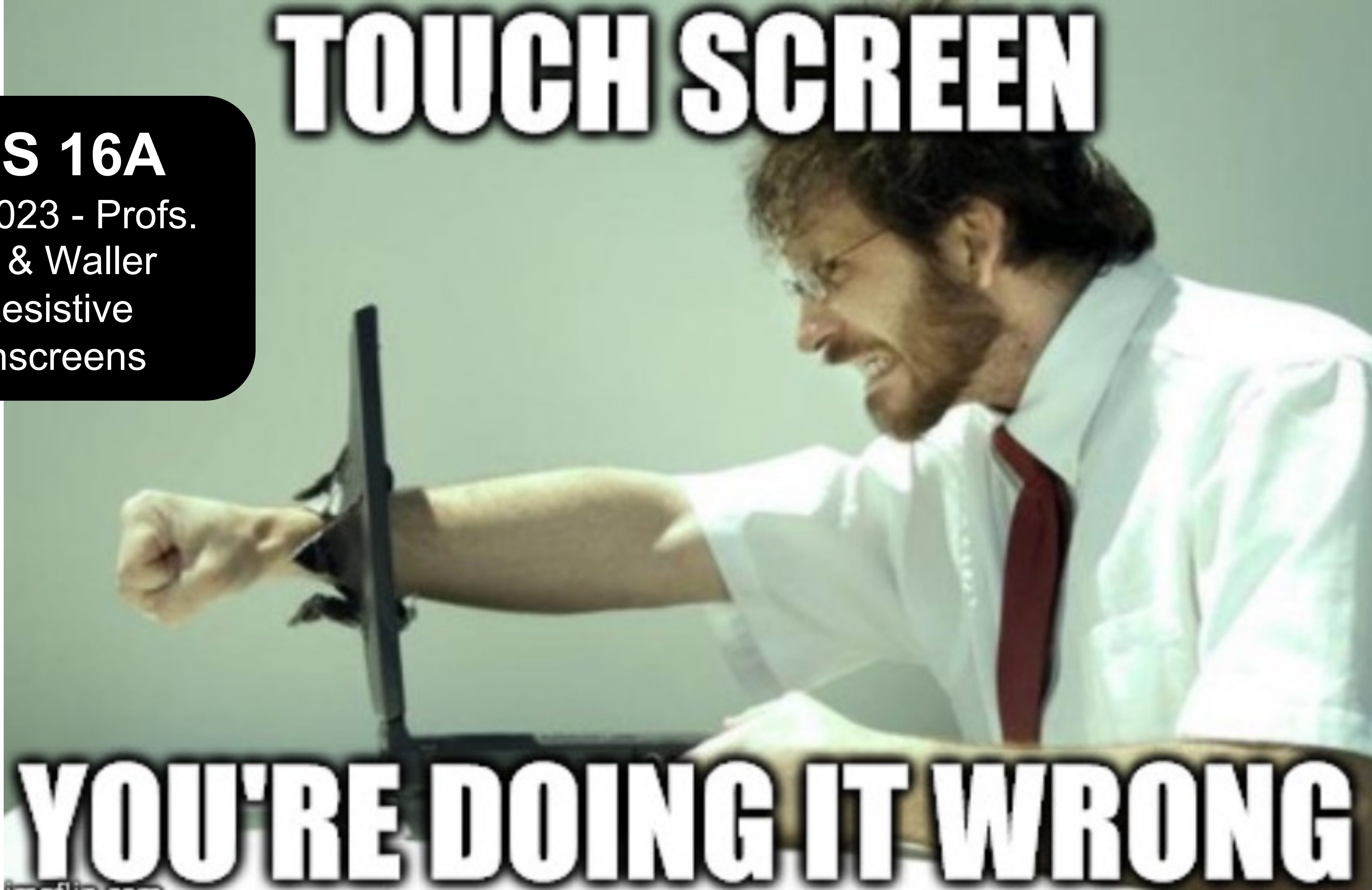
EECS 16A

Spring 2023 - Profs.
Muller & Waller
2D Resistive
Touchscreens

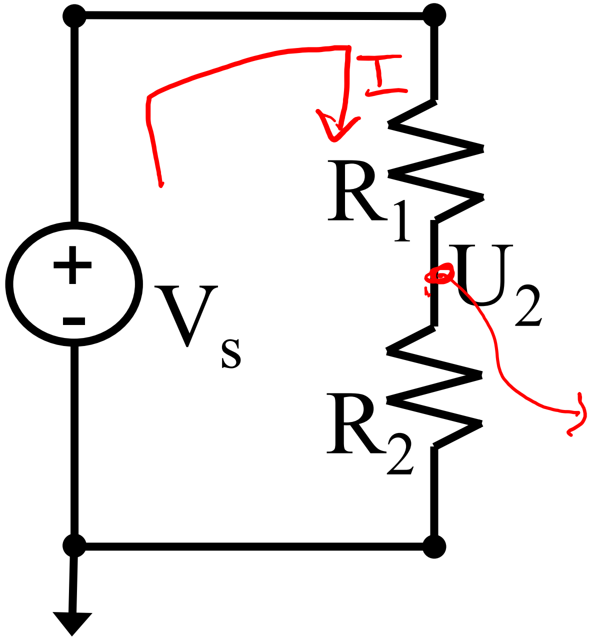


Toolbox

- ✓ *KVL: Voltage drops around a loop sum to 0*
- ✓ *KCL: All currents coming out of a node sum to 0*
- ✓ $V = IR$
- ✓ $P = IV$

$R = \rho L / A$

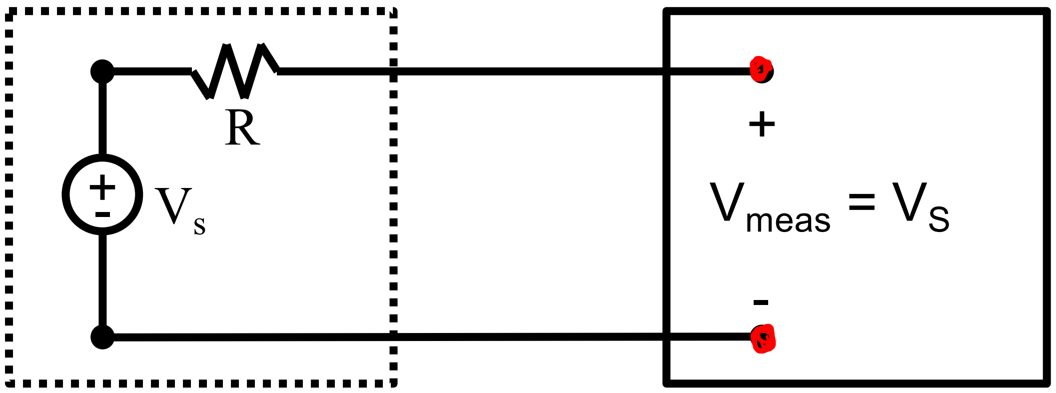
Voltage Divider



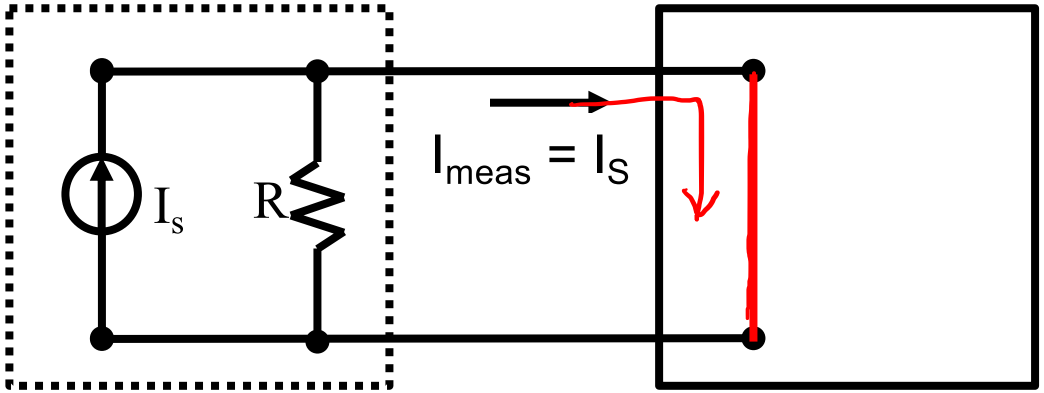
$$I = \frac{V_S}{R_1 + R_2}$$

$$U_2 = \frac{V_S R_2}{R_1 + R_2}$$

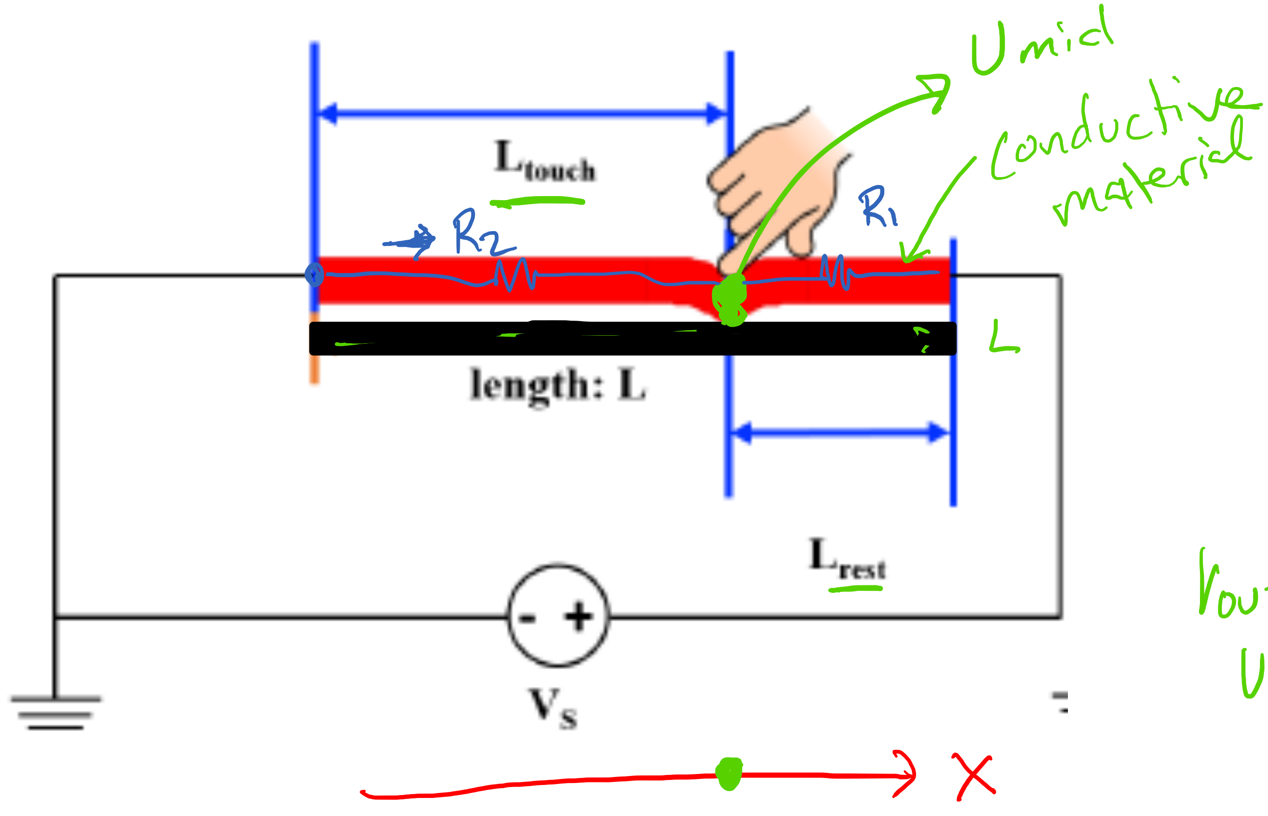
V Measurement Circuit



I Measurement Circuit



Recap: Resistive Touch Screen – More realistic model

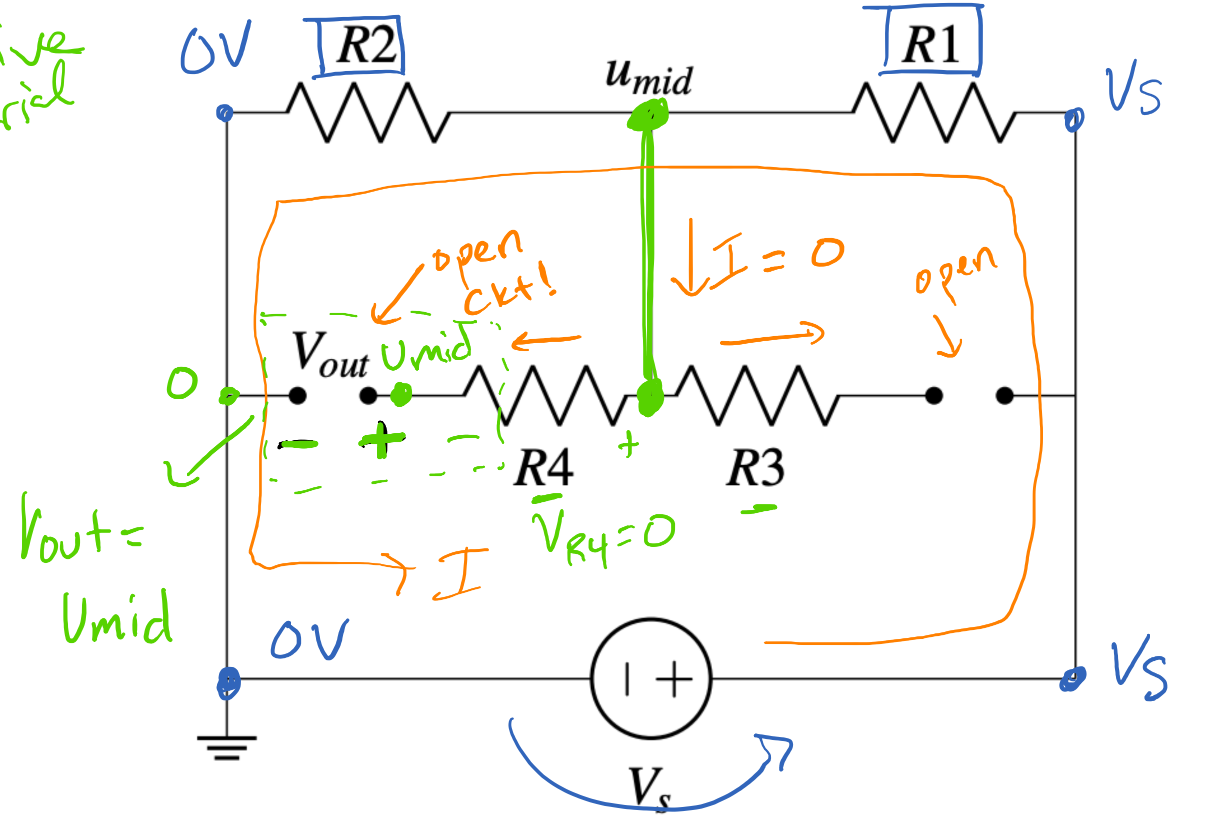


$$R = \frac{\rho L}{A}$$

$$L = L_{touch} + L_{rest}$$

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

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



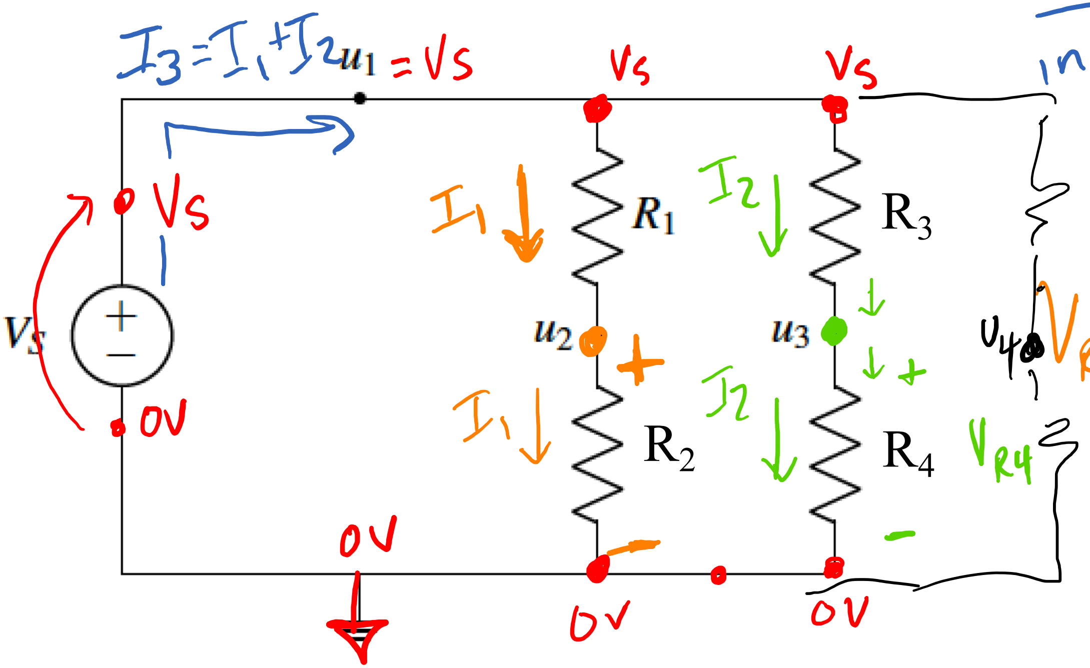
Voltage Divider

$$U_{mid} = V_s \cdot \frac{R_2}{R_1 + R_2} = V_s \frac{\rho L_{touch}/A}{\rho L_{rest}/A + \frac{\rho L_{touch}}{A}} = \frac{V_s L_{touch}}{L}$$

An Interesting Circuit

$I_3 = I_1 + I_2$

in — out



$I_1 = \frac{V_s}{R_1 + R_2}$

$I_2 = \frac{V_s}{R_3 + R_4}$

$V_{R2} = U_2 - 0 = I_1 R_2$

$V_{R4} = U_3 - 0 = I_2 R_4$

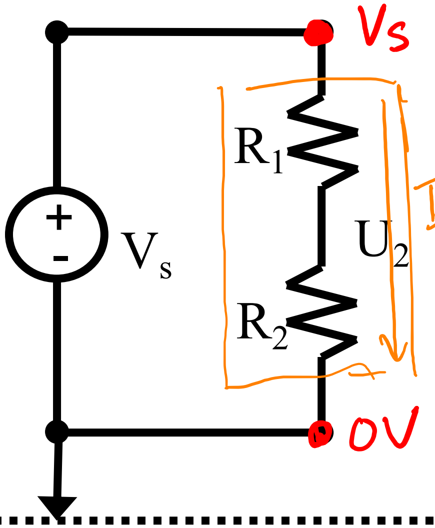
$V_{R2} = U_2 = \frac{V_s R_2}{R_1 + R_2}$

$U_3 = \frac{V_s R_4}{R_3 + R_4}$

same!

same!

Note 14



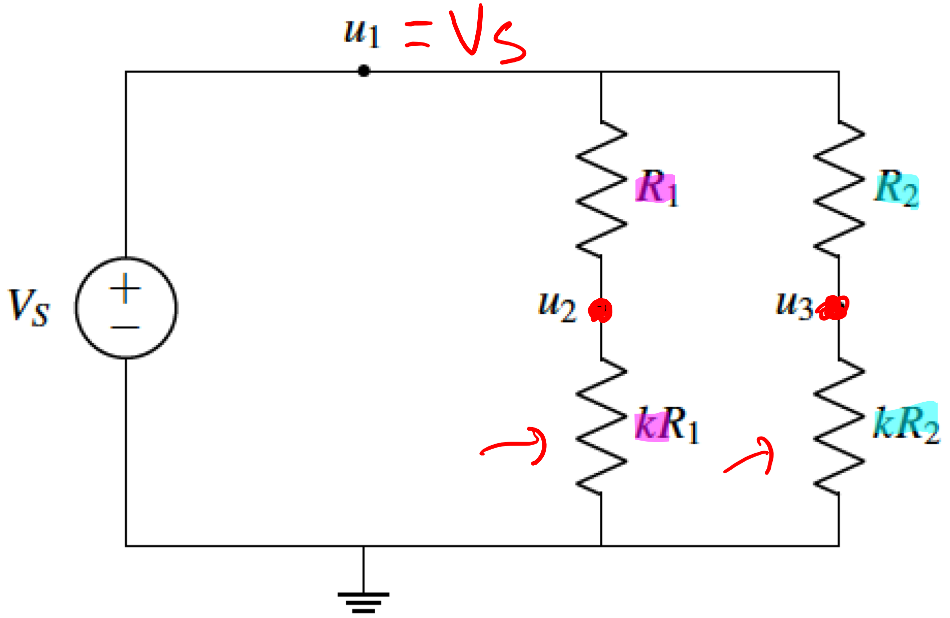
$$I = \frac{V_S}{R_1 + R_2}$$

$$U_2 = \frac{V_S R_2}{R_1 + R_2}$$

more branches? no problem

solve U_4 same way

An Interesting Circuit



Note 14

$$U_2 = \frac{V_S \cdot kR_1}{kR_1 + R_1}$$

$$U_3 = \frac{V_S \cdot kR_2}{kR_2 + R_2}$$

$$U_2 = \frac{V_S \cdot k}{k+1}$$

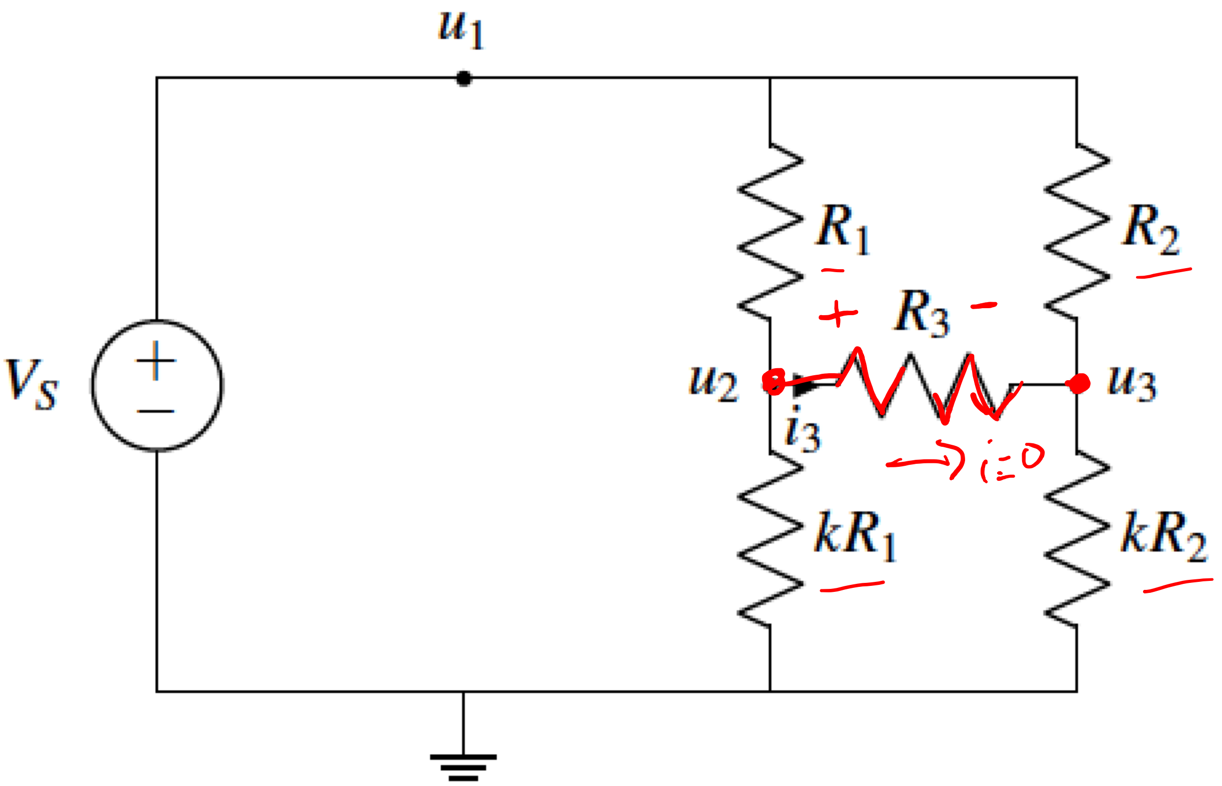
$$U_3 = \frac{V_S\, k}{k+1}$$

* independent of resistance value

→ only ratio is important

* $U_2 = U_3$!!!

Let's add one more resistor – what is i_3?



$U_2 = U_3$

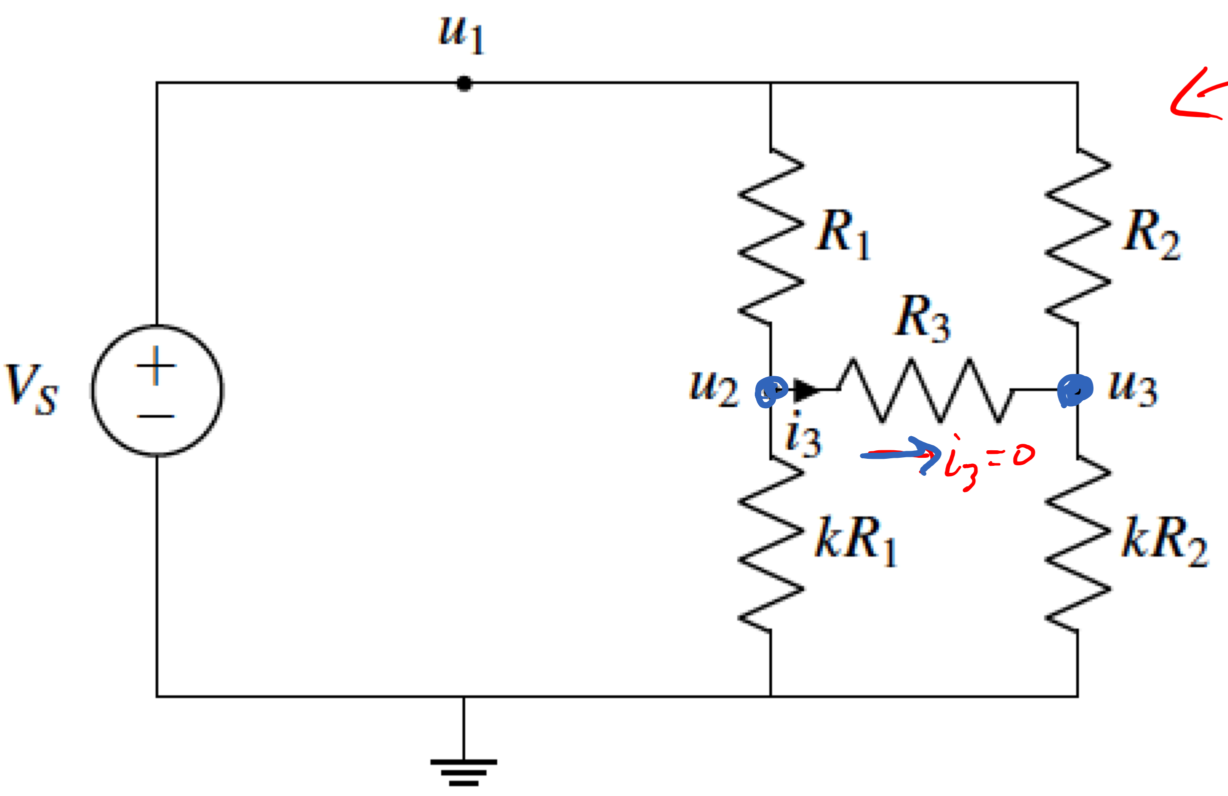
$i_3 = ?$

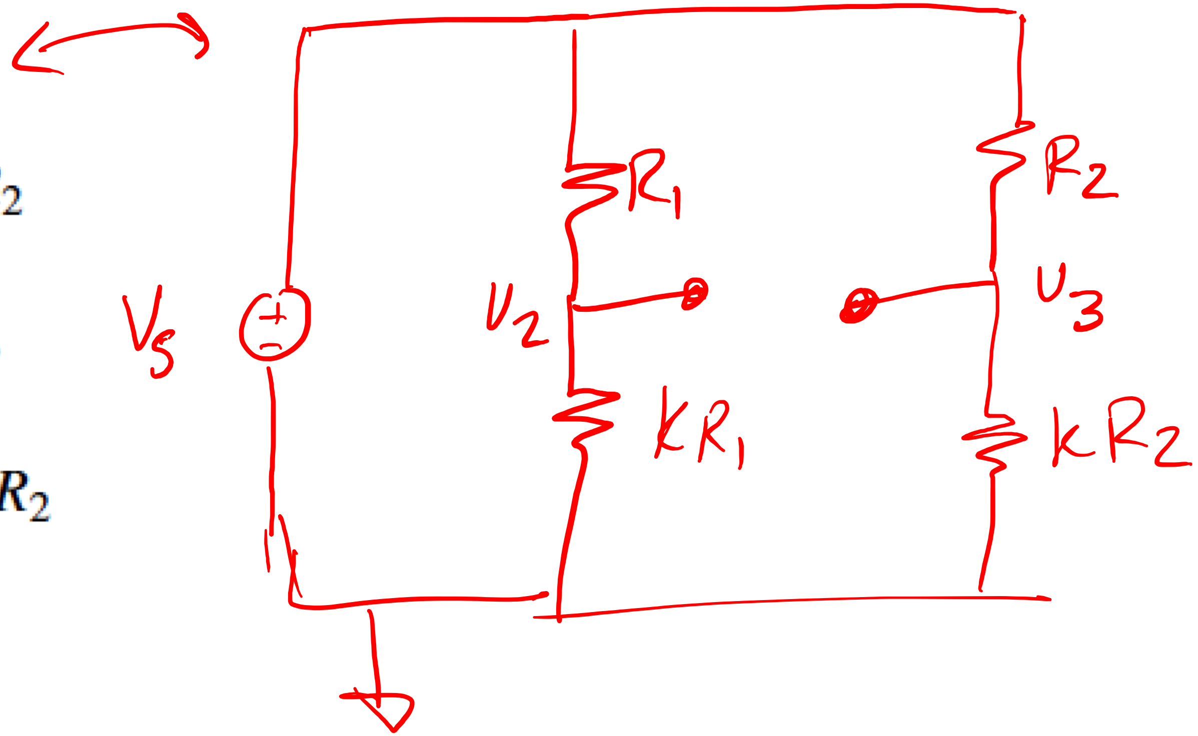
$V_{R3} = U_2 - U_3 = i_3 R_3$

$= 0$

$\therefore i_3 = 0$

Let's add one more resistor – *equivalent* circuit

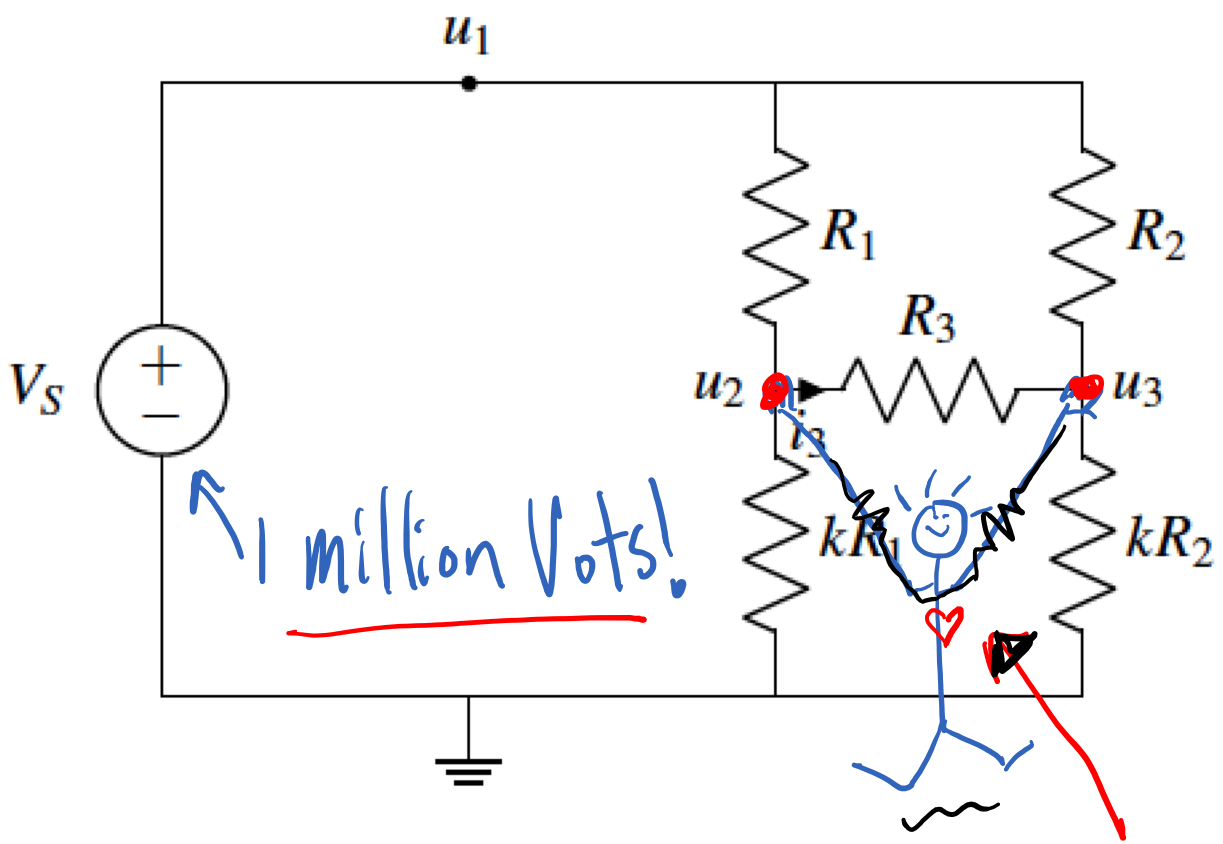


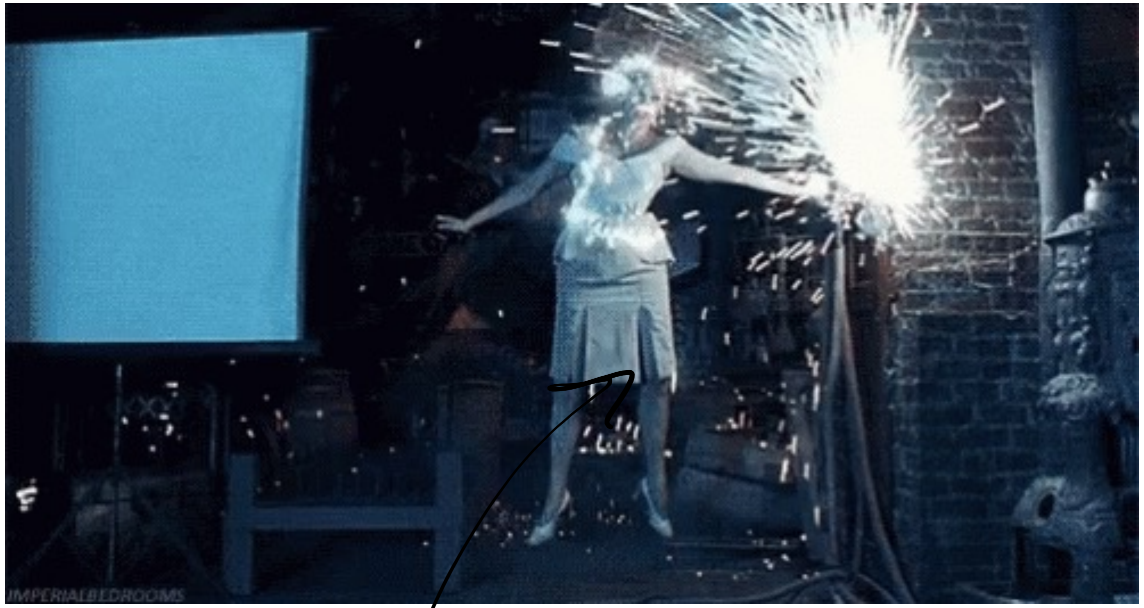


an open circuit also has $i=0$

functionally these circuits are equivalent

Who's willing to be R3?





Resistor tolerance?

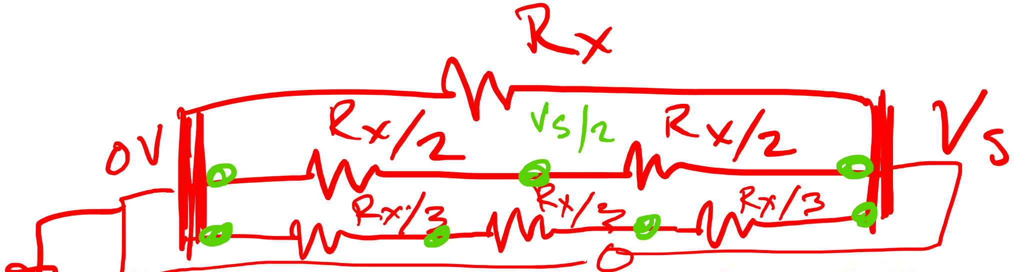
~1%

~100 mA to stop a human heart!

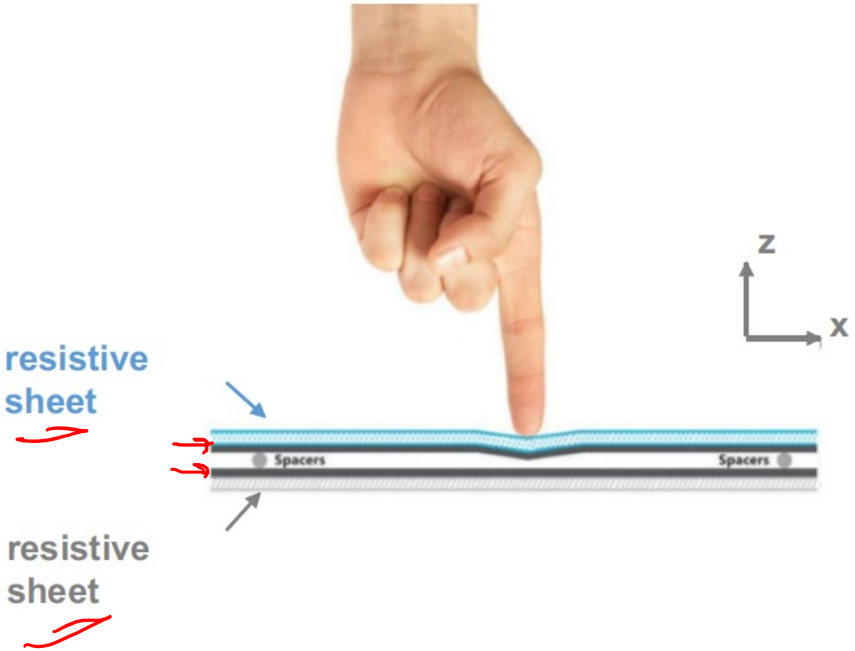
= 0.1 A

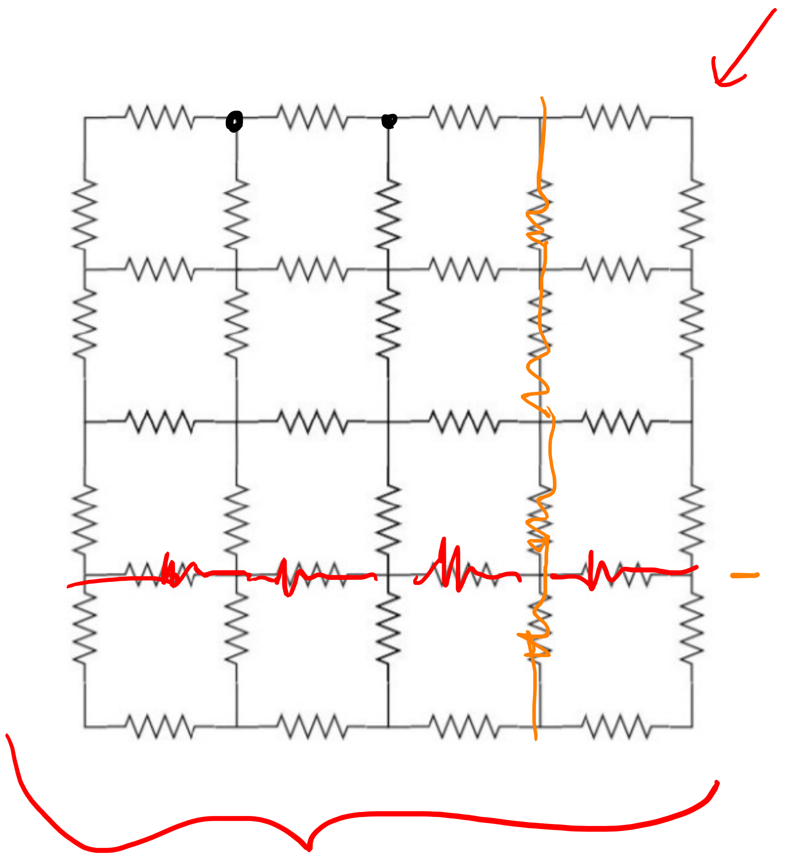
$V_{R3} \Rightarrow$ 10,000 Volts! ← what's the resistance of a human?

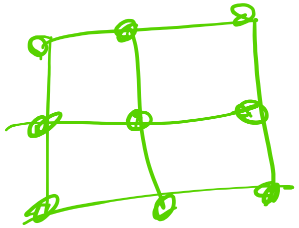
2D Touch Screen

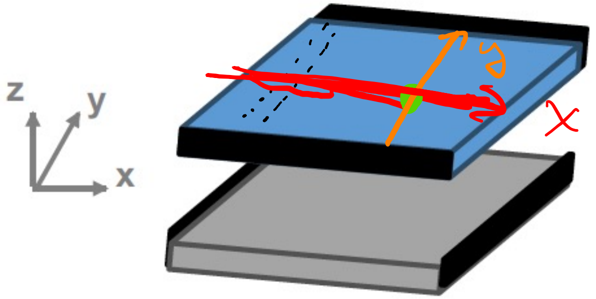


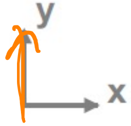
Our circuit model for each resistive sheet is a grid of resistors:



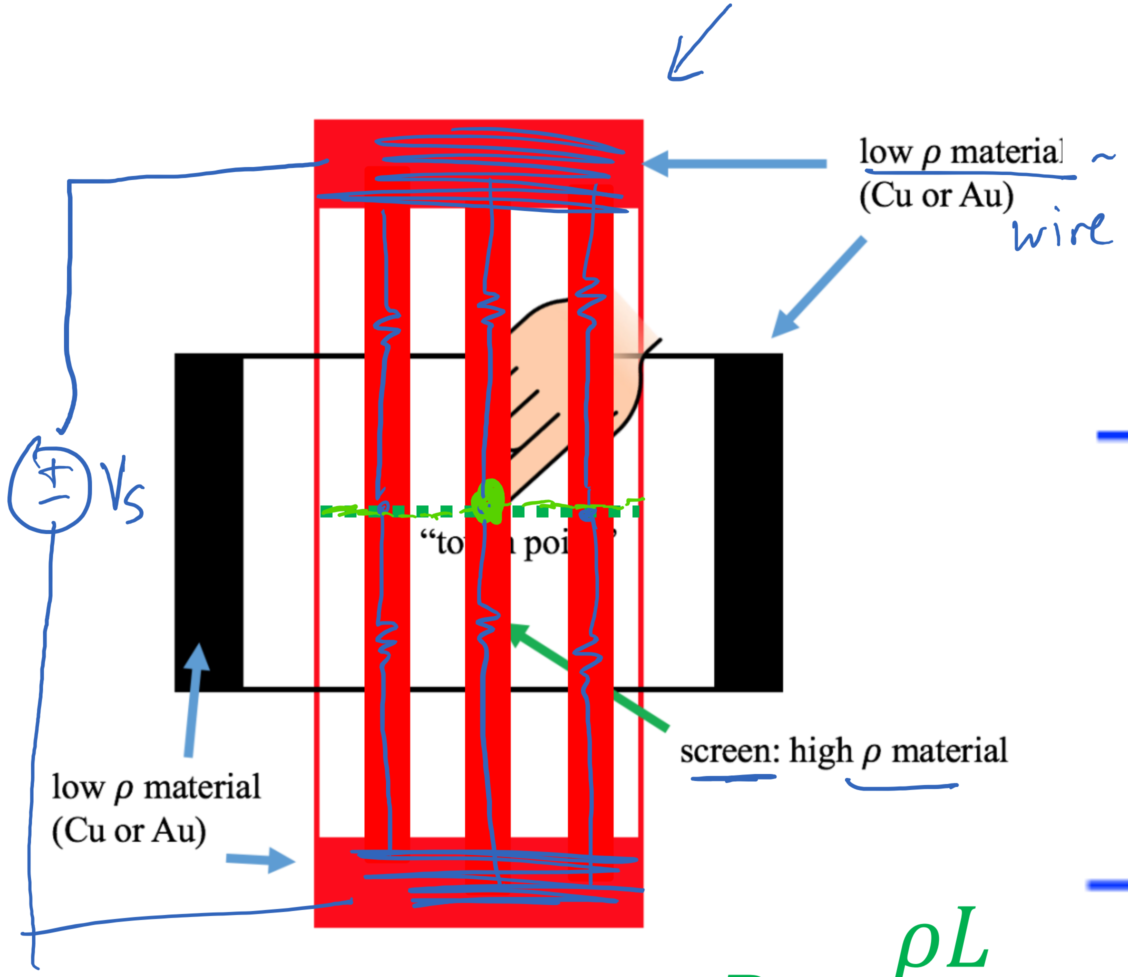


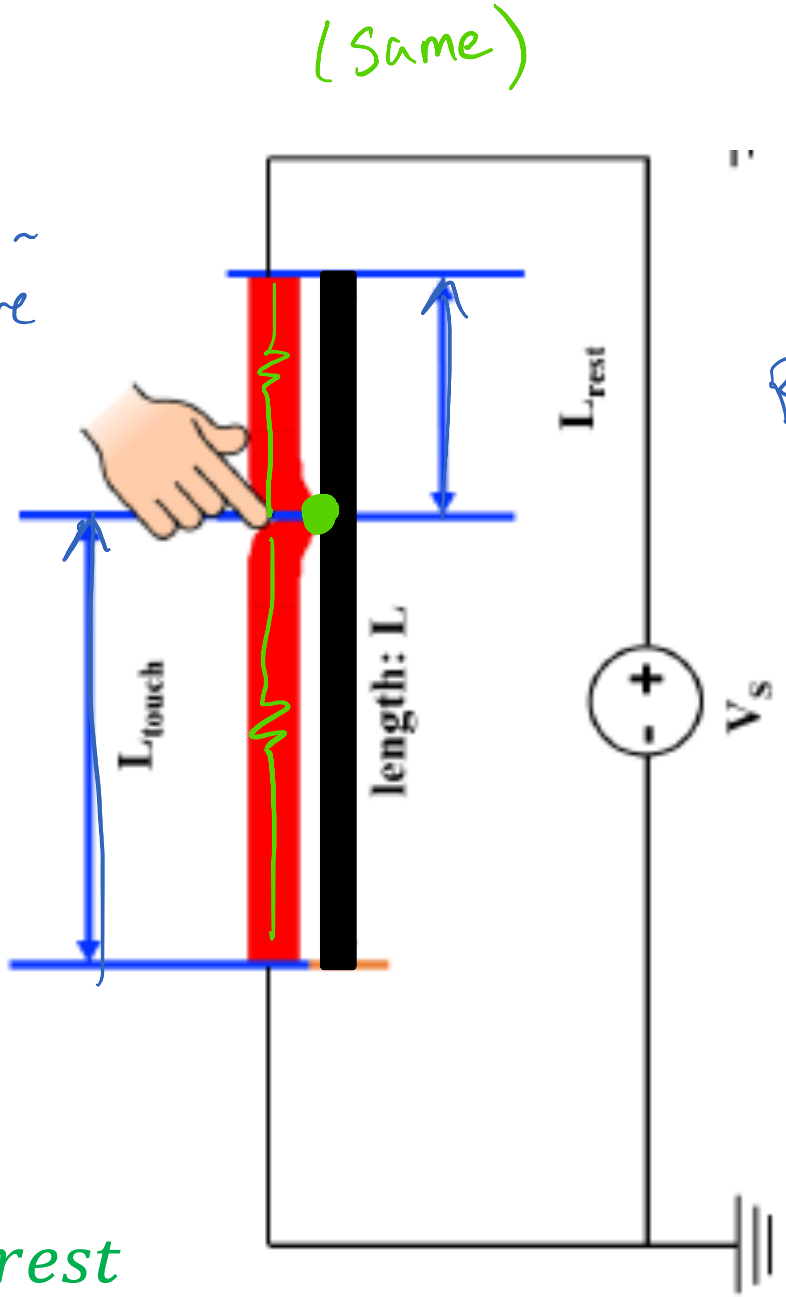


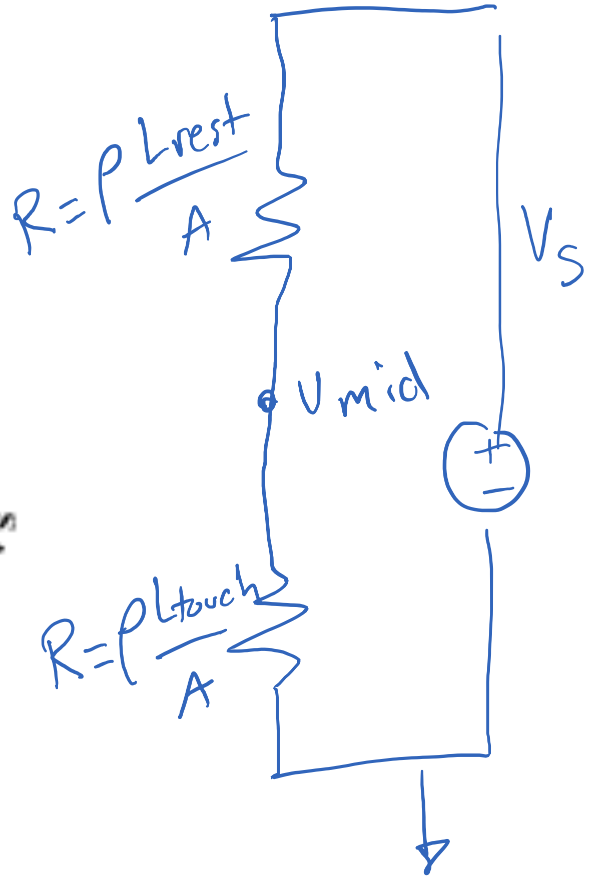


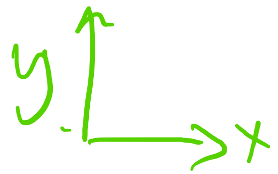


2D Touch Screen





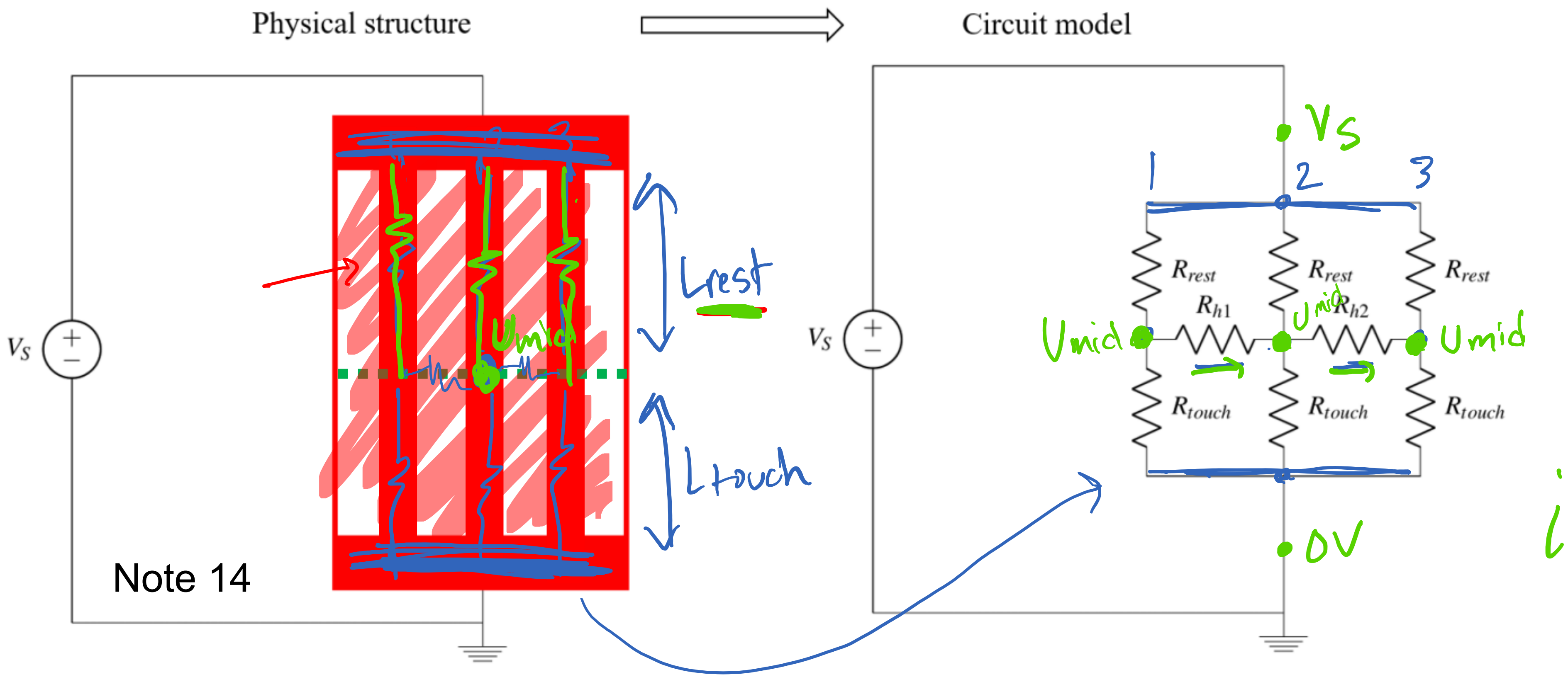




$$R = \frac{\rho L}{A}$$

$$L = L_{touch} + L_{rest}$$

Top Plate Circuit Model



Why R_{h1}, R_{h2}?

(Volt. divider)

$$U_{mid} = \frac{V_S \cdot R_{touch}}{R_{touch} + R_{rest}}$$

$$i_{R_{h1}} = 0 \quad V_{R_{h1}} = 0$$

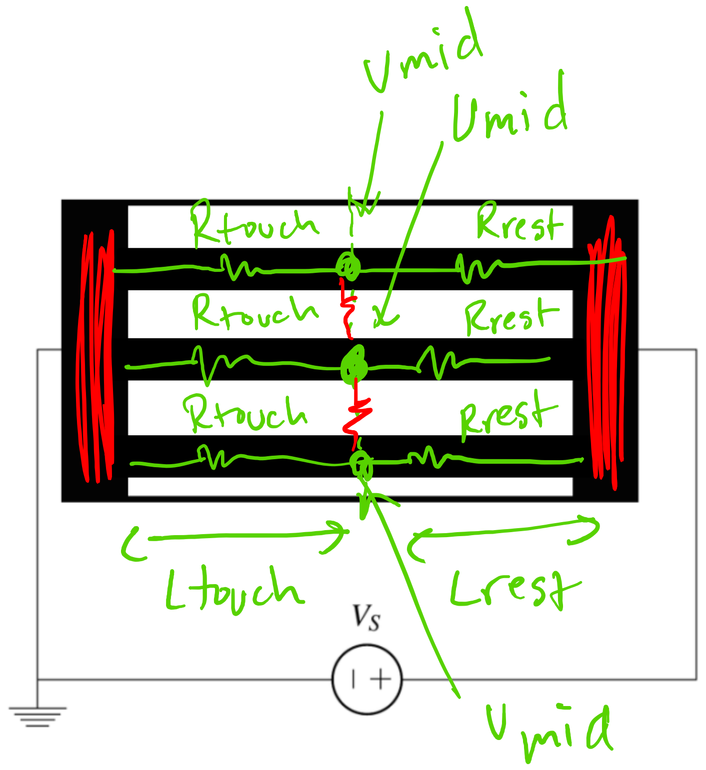
$$R = \frac{\rho L}{A}$$

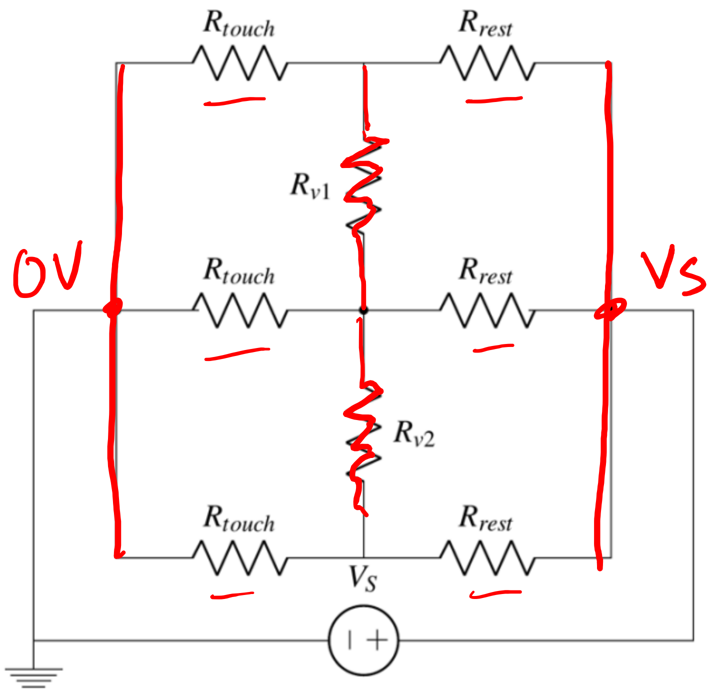
$$L = L_{touch} + L_{rest}$$

$$U_{mid} = V_S \cdot \frac{\rho L_{touch} / A}{\rho L_{touch}/A + \rho L_{rest}/A} = \frac{V_S L_{touch}}{L}$$

Bottom Plate Model

Physical structure ⟹ Circuit model



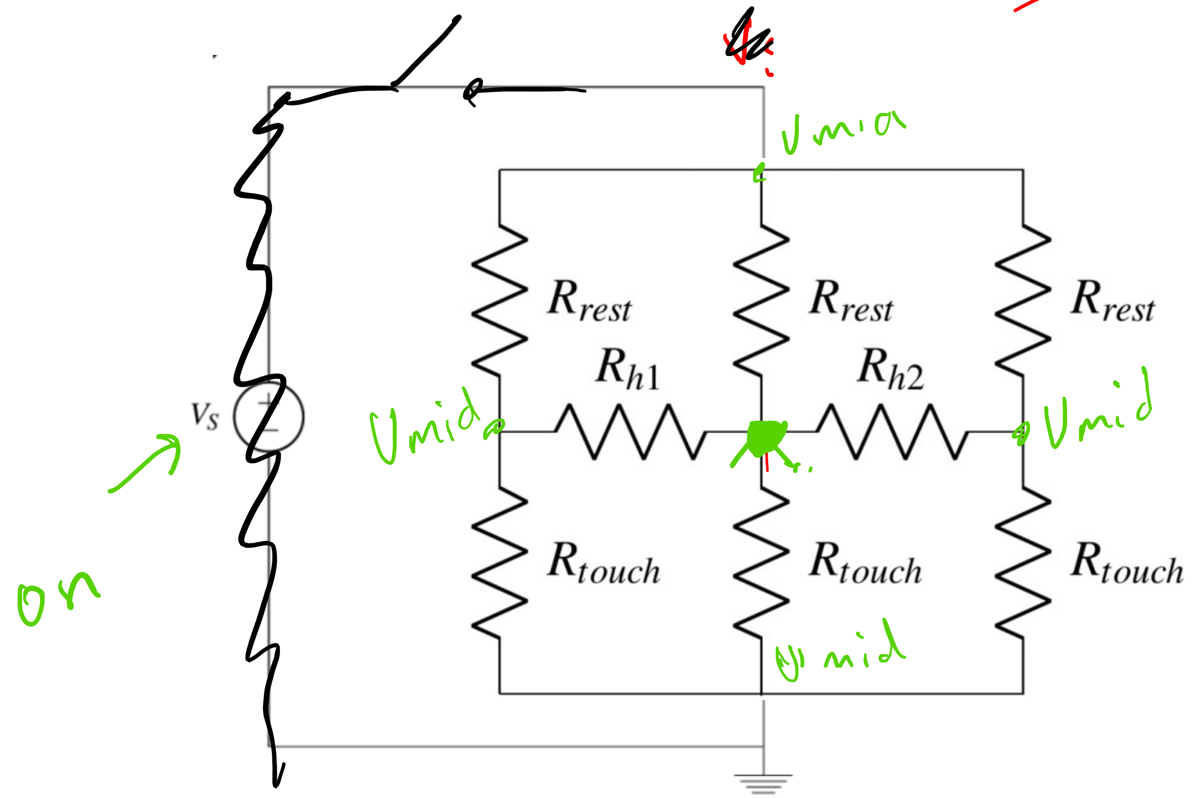


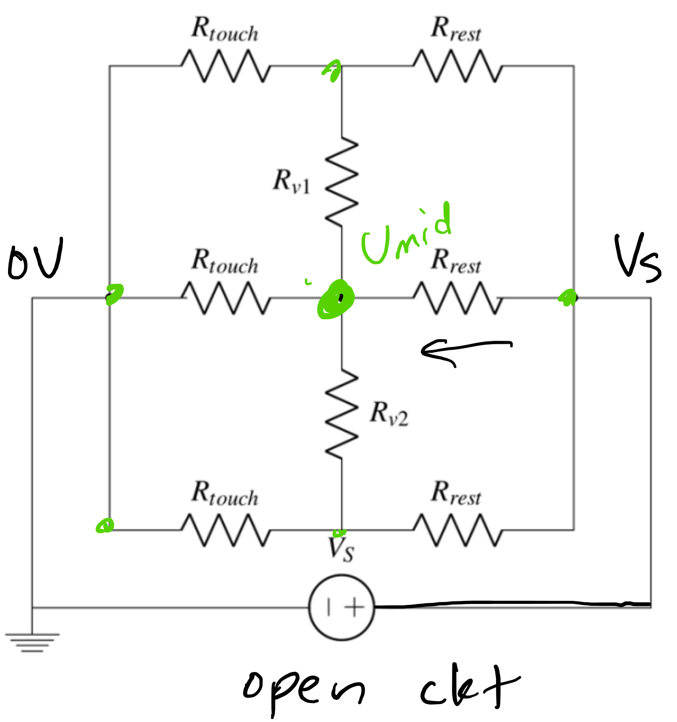
Note 14

→ x

Touchscreen Readout

rotate 90°





$U_{mid} = \frac{V_S\, L_{touch}}{L}$

1st - power vertical

Vertical Measurement

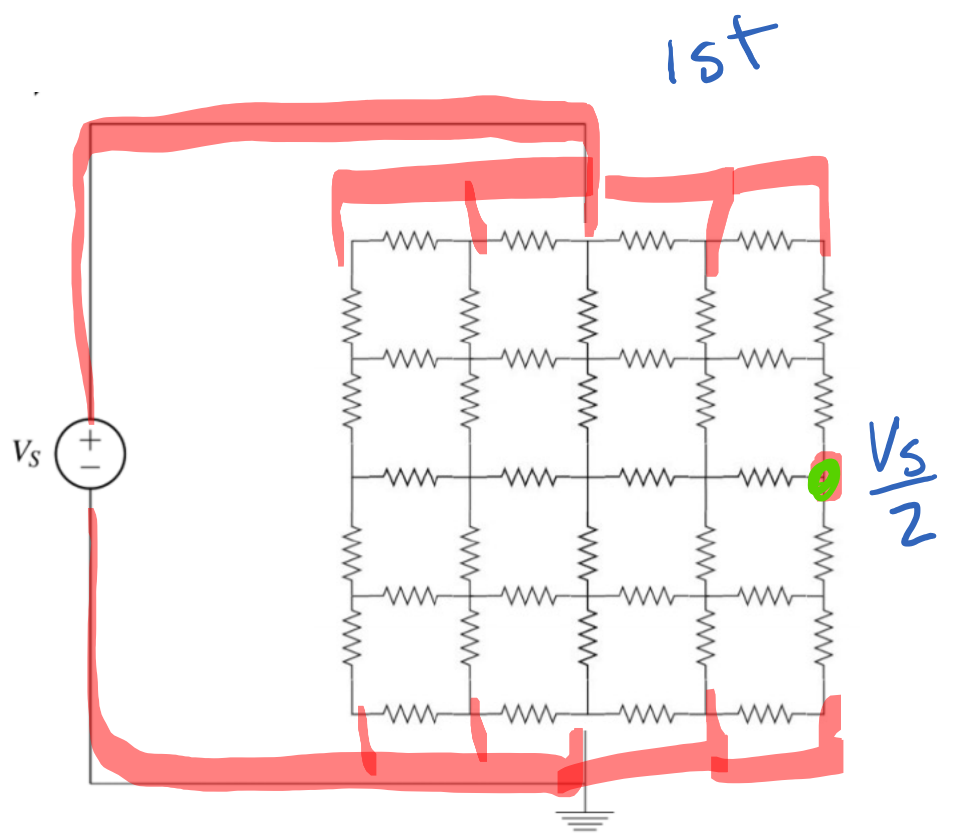
1st y-touch position →

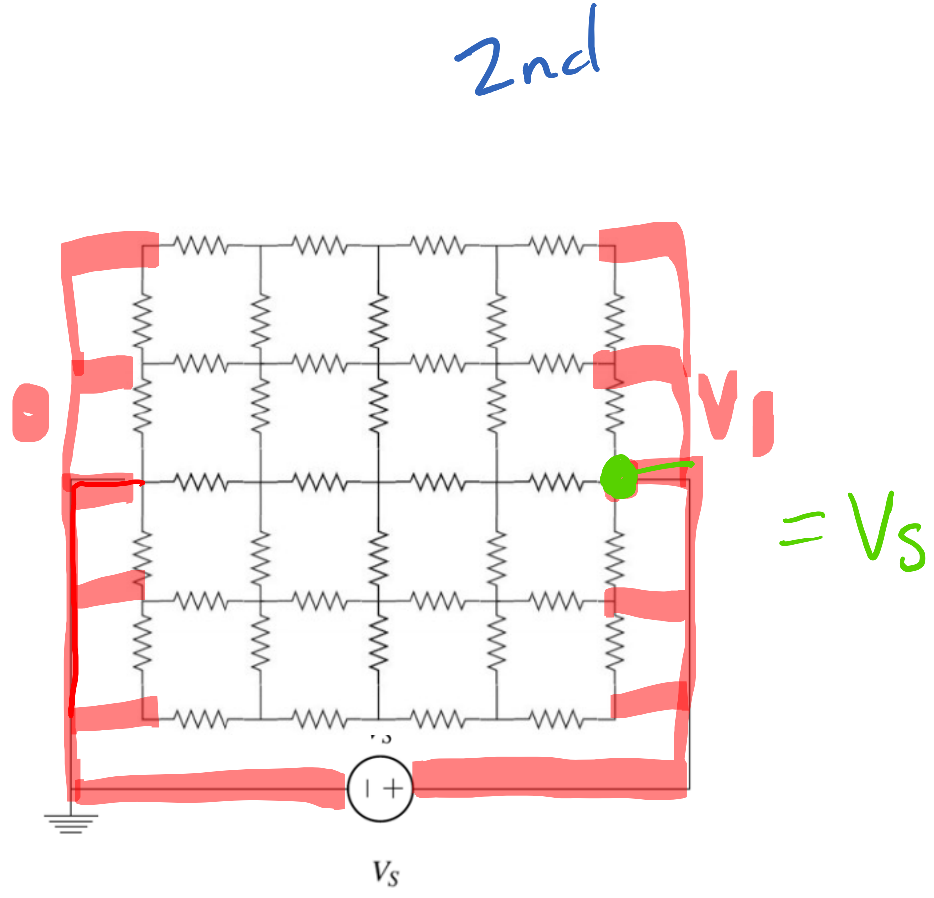
Horizontal Measurement

2nd x-touch position →

ping pong

Touchscreen Readout – More realistic model





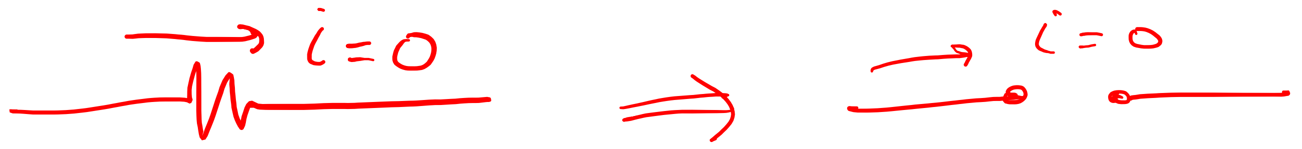
Vertical Measurement
y-touch position

$\frac{V_s}{2} = \frac{Y_{max}}{2}$

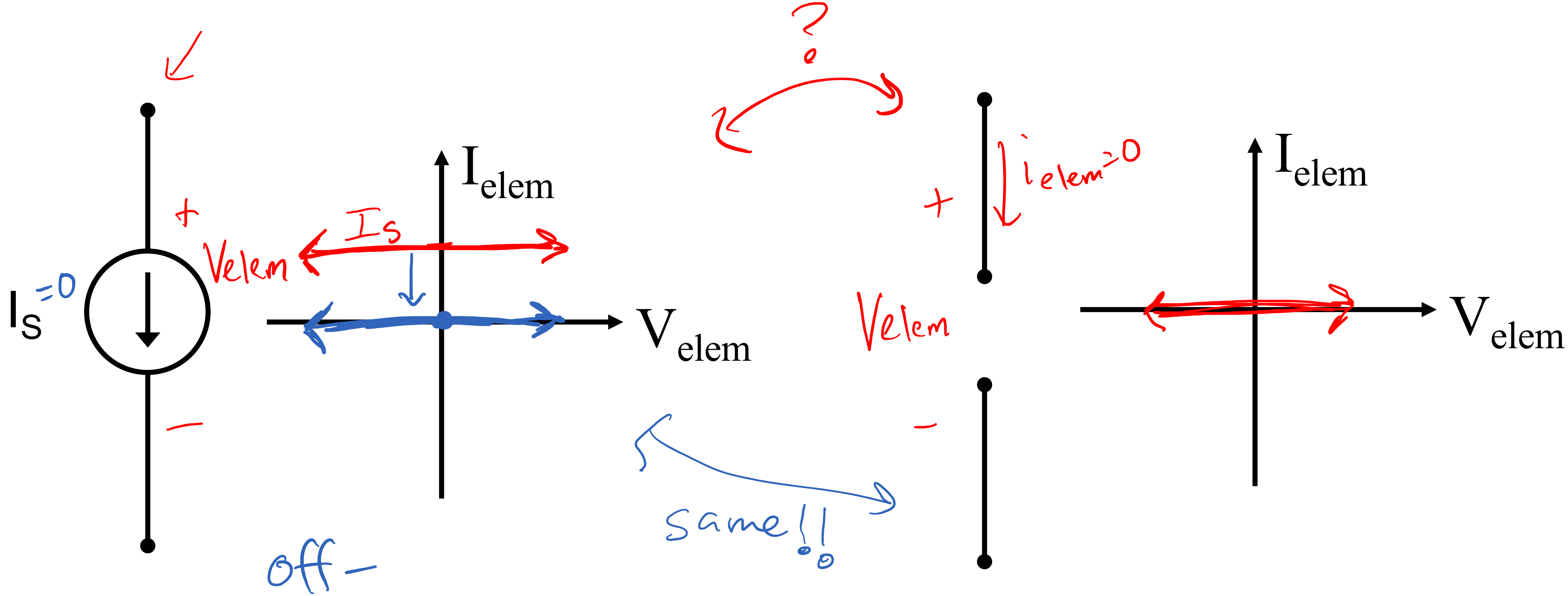
Horizontal Measurement
x-touch position

$V_s = X_{max}$

Equivalence



* Two circuits are equivalent if they have the same IV relationship



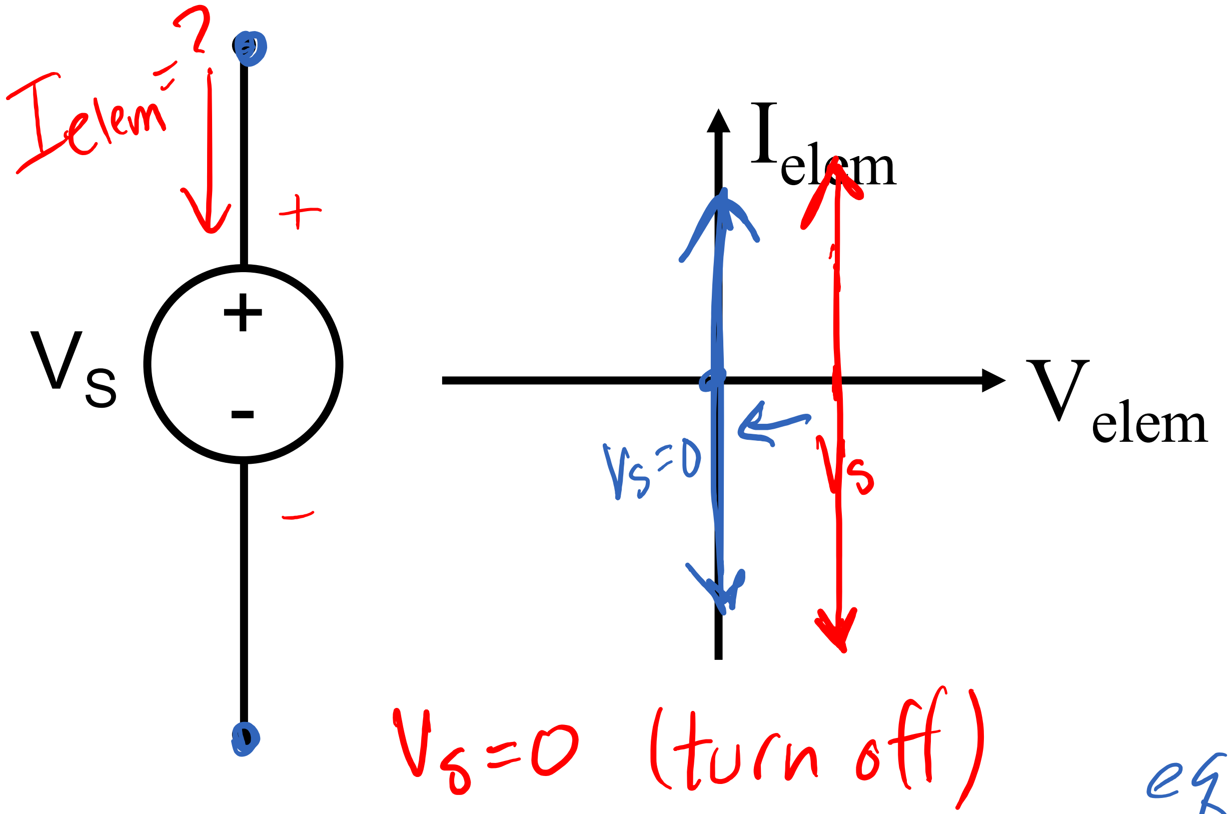
Current Source

Open Circuit

Equivalence

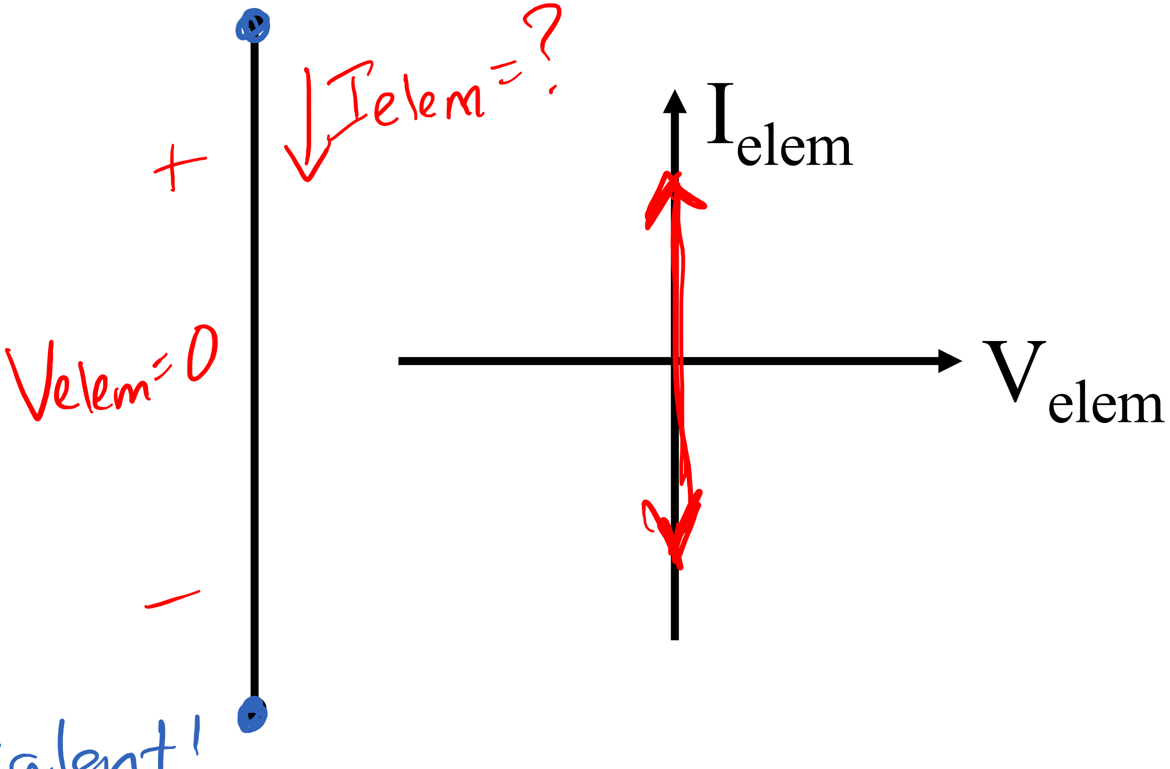
allows circuit simplification

Two circuits are equivalent if they have the same IV relationship



Voltage Source

equivalent!



Wire