EECS 16A Dis 7B Notes

Monday, October 11, 2021 3:38 PM

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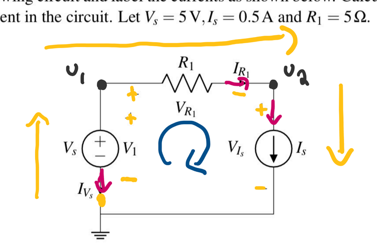
1. Passive Sign Convention and Power v 2.0

Suppose we have the following circuit and label the currents as shown below. Calculate the power dissipated or supplied by every element in the circuit. Let $V_s = 5\,V, I_s = 0.5\,A$ and $R_1 = 5\,\Omega$.



KVL: $\sum^{loop}$ voltages $= 0$

$V_1 - V_{R_1} - V_{I_s} = 0$

$V_1 = V_s$

$V_s - V_{R_1} - V_{I_s} = 0$

KCL: @ v_1: $I_{V_s} + I_{R_1} = 0$ (1)

@ v_2: $I_{R_1} = I_s$ (2)

$V_s = 5V$ $I_s = .5A$ $R_1 = 5\Omega$

$I_s = .5A = I_{R_1}$

$I_{V_s} = -.5A$

KVL: $V_s - V_{R_1} - V_{I_s} = 0$ $5V - I_R \cdot R - V_{I_s} = 0$ $5V - .5A \cdot 5\Omega - V_{I_s} = 0$

$5V - V_{R_1} - V_{I_s} = 0$ $5V - 5\Omega \cdot .5A - V_{I_s} = 0$ $V_{I_s} = 2.5V$

Power = $P = IV$

$V = IR$ $P = I^2R$ $= \frac{V^2}{R}$ } only for resistors

Voltage Source: $P = IV$

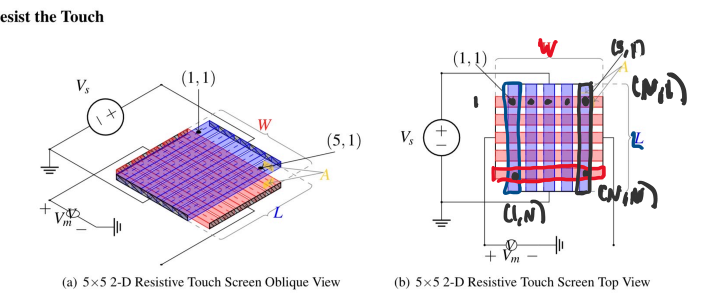
$P = I_{V_s} \cdot V_s = -.5A \cdot 5V = -2.5W$ (supplied)

Resistor: $P_R = I_R \cdot V_R = .5A \cdot 2.5V = 1.25W$ (dissipating)

Current Source: $P_{I_s} = I_s \cdot V_{I_s} = .5A \cdot 2.5V = 1.25W$ (dissipating)

} Powers should sum up to 0 ✓

2. Resist the Touch



(a) 5×5 2-D Resistive Touch Screen Oblique View (b) 5×5 2-D Resistive Touch Screen Top View

Figure 1: $N \times N$ Resistive Touch Screen, $N = 5$

In this question we will be re-examining the 2-dimensional resistive touchscreen. This touchscreen, is slightly different to the one shown in lecture and more like the one we will be examining in lab.

The touchscreen has length L and width W and is composed of a rigid bottom-layer and a flexible top-layer. Instead of a having a two continuous resistive sheets on the top and bottom layers, this is a simpler implementation with N vertical strips of conductive material in the top layer and N horizontal strips of conductive material in the bottom layer. The strips of a single layer are all connected by an ideal conducting plate on each side. All strips have resistivity, ρ, and cross-sectional area, A.

Assume that all top layer resistive strips and bottom layer resistive strips are spaced apart equally, and that the upper left touch point in Figure 1(b) is position $(1,1)$, and the upper right touch point is $(N,1)$. The spacing between the strips in the top layer is $\frac{W}{N+1}$, and the spacing between the strips in the bottom layer is $\frac{L}{N+1}$.

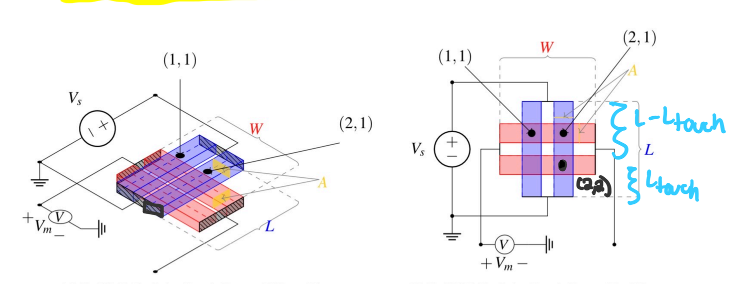
(a) Find the resistance R_y for a single vertical blue strip and R_x for a single horizontal red strip, as a function of the screen dimensions W and L, the strip resistivity ρ, and the cross-sectional area A.

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

$R_y = \frac{\rho \cdot L}{A}$ $R_x = \frac{\rho \cdot W}{A}$

(b) Consider a 2 × 2 example for the touchscreen circuit, shown in Figure 2.

Assume that we connect a voltage source V_s, between the top and bottom terminals of the blue strips, and a voltmeter V_m to one of the left or right terminals as depicted in the diagram.

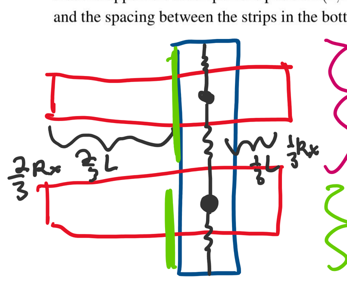


(a) 2×2 2-D Resistive Touch Screen Oblique View (b) 2×2 2-D Resistive Touch Screen Top View

Figure 2: 2 × 2 Resistive Touch Screen

If $V_s = 3\,V$, $R_x = 2000\,\Omega$, and $R_y = 2000\,\Omega$, draw the equivalent circuit for when the point $(2,2)$ is pressed and solve for the measured voltage, V_m, with respect to ground.

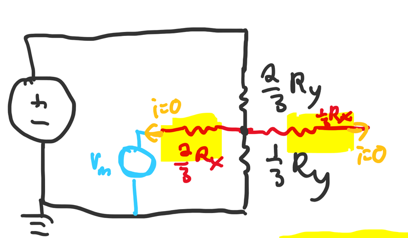
Reminder: all top layer resistive strips and bottom layer resistive strips are spaced apart equally, and that the upper left touch point is position $(1,1)$. The spacing between the strips in the top layer is $\frac{W}{N+1}$, and the spacing between the strips in the bottom layer is $\frac{L}{N+1}$.



$\frac{2}{3}L \leftrightarrow \frac{2}{3}R_y$

$\frac{1}{3}L \leftrightarrow \frac{1}{3}R_y$

$R = \frac{\rho l}{A} = \frac{\rho \cdot \frac{1}{3}L}{A} = \frac{1}{3}\left(\frac{\rho L}{A}\right) = \frac{1}{3}R_y$

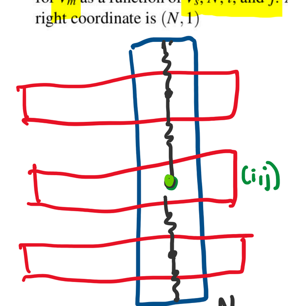


$V_m = \frac{\frac{1}{3}R_y}{\frac{1}{3}R_y + \frac{2}{3}R_y} \cdot V_s = \frac{1}{3}V_s$

(c) Suppose a touch occurs at coordinates (i, j) for an arbitrary $N \times N$ touchscreen, and the voltage source and meter are connected as in the figures. A 5 × 5 example is shown in Figure 1(b). Find an expression for V_m as a function of V_s, N, i, and j. Again, the upper left corner is the coordinate $(1,1)$ and the upper right coordinate is $(N,1)$

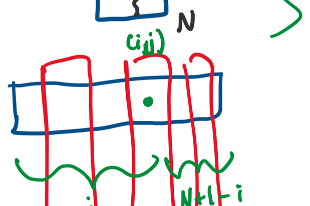
Where does N+1 come from?

There are N+1 resistors for a strip of length N



$\left(\frac{j}{N+1}\right)V_s$

$\left(\frac{N+1-j}{N+1}\right)V_s$



$\left(\frac{i}{N+1}\right)V_s$

$\left(\frac{N+1-i}{N+1}\right)V_s$

$V_m = \left(\frac{N+1-j}{N+1}\right)V_s$

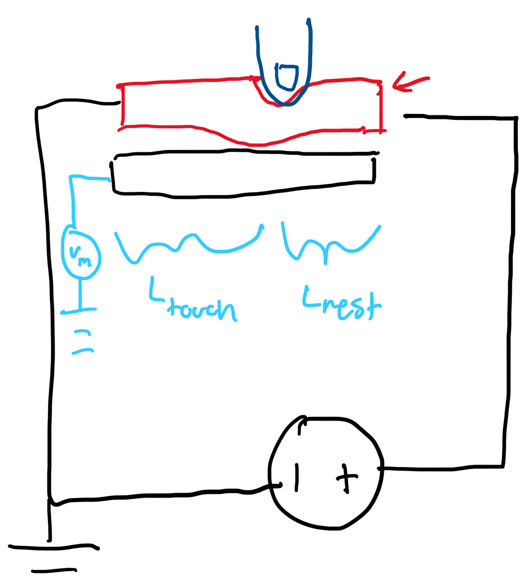
When top layer is connected to V_s & bottom layer is connected to voltmeter

(d) Optional / Fun: Experiment with the TinkerCad models below to validate the theoretical results you just derived.

TinkerCad model of 2 × 2 equivalent circuit: https://www.tinkercad.com/things/0wIXz3MkD7B

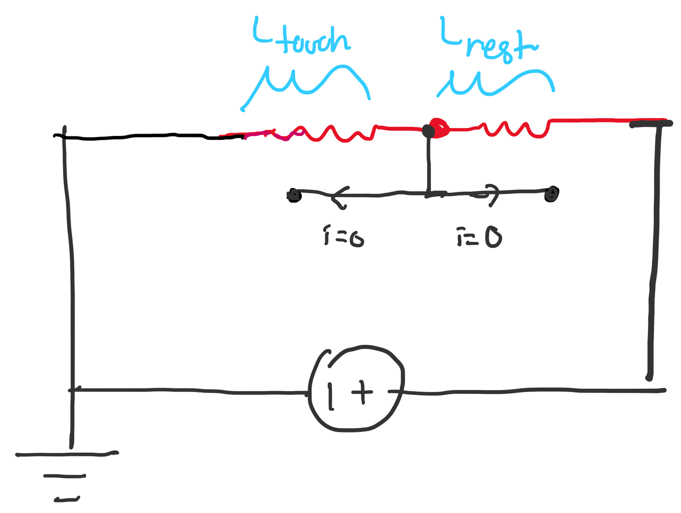
TinkerCad model of 3 × 2 equivalent circuit: https://www.tinkercad.com/things/k5oolj2tUEN

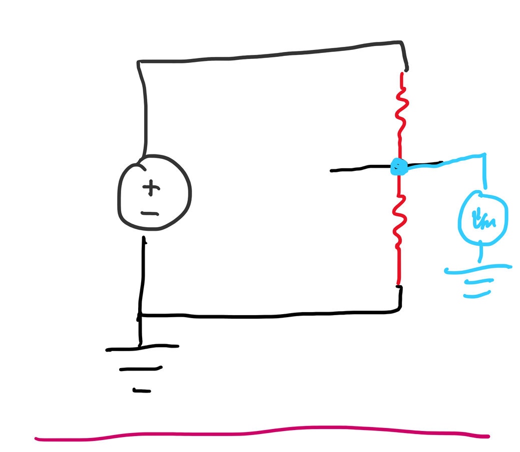
1D touchscreen

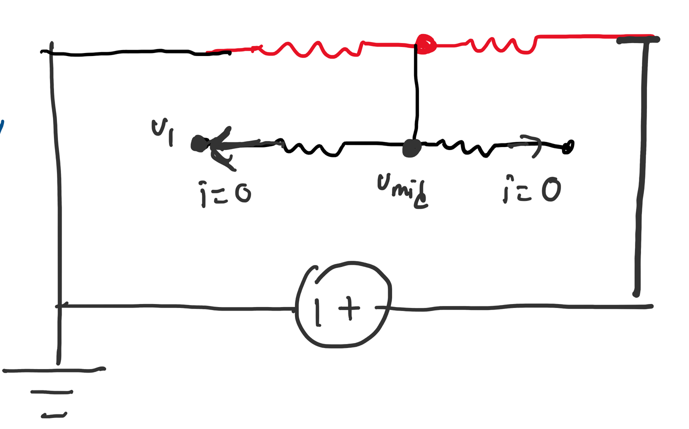


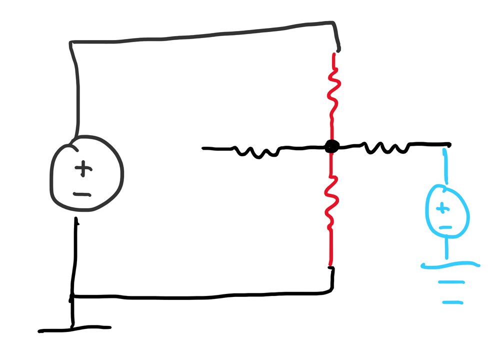
Bottom layer has $\rho = 0$

Bottom layer has $\rho \neq 0$





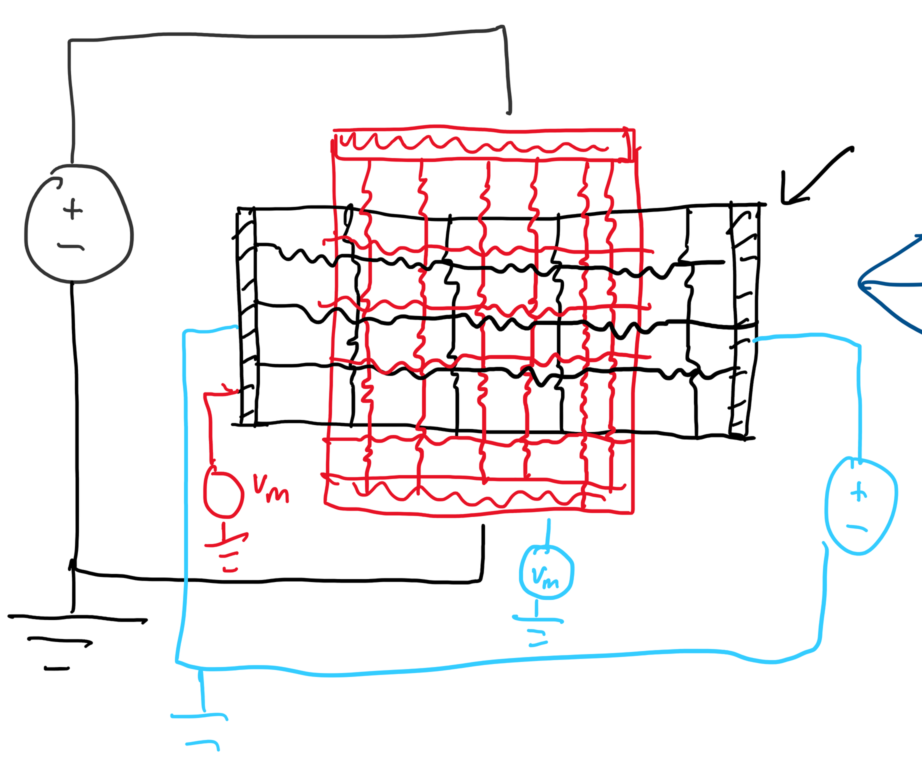




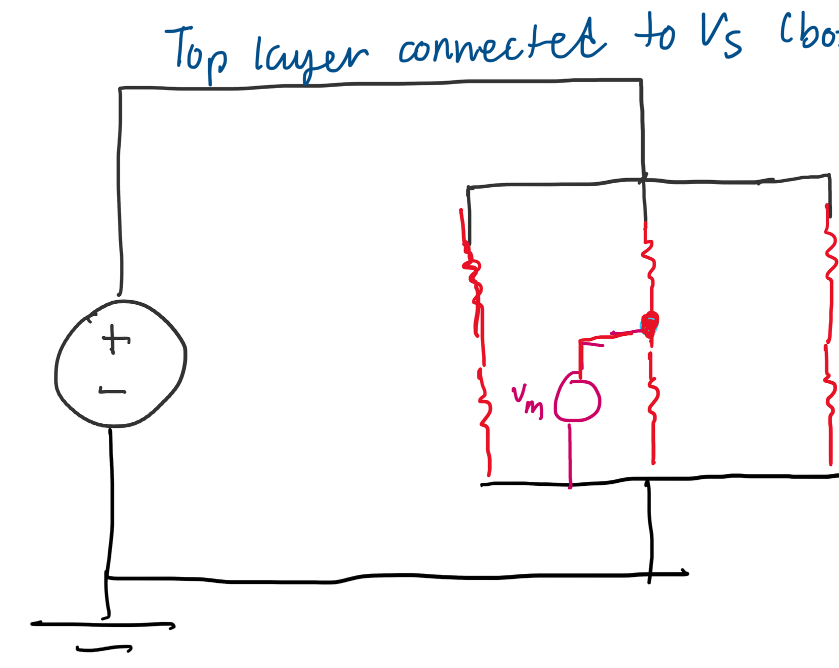
$v_{mid} - v_1 = i \cdot R$

$v_{mid} = v_1$ 0

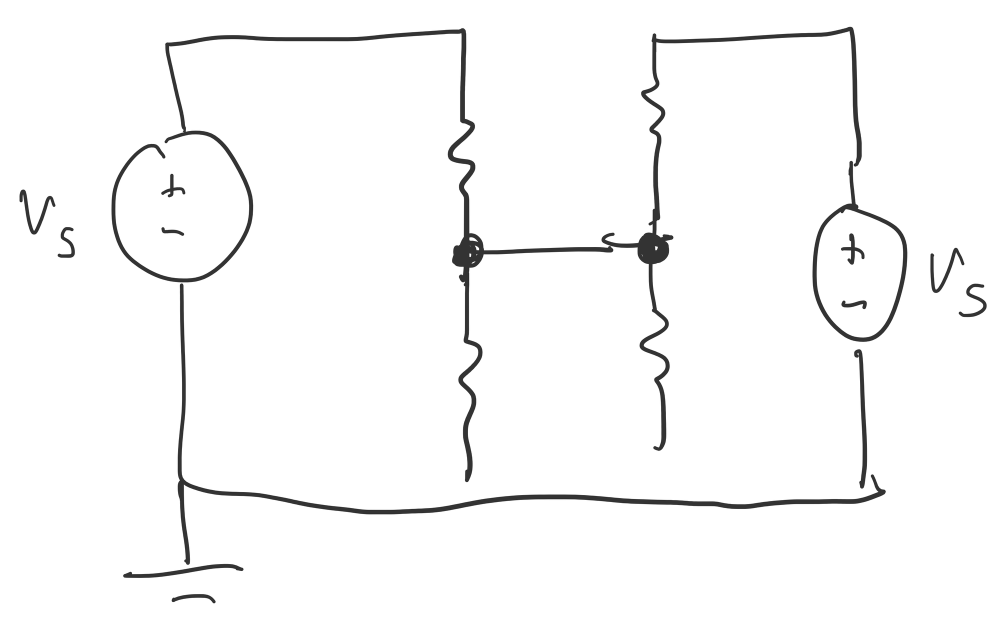
2D Touchscreen

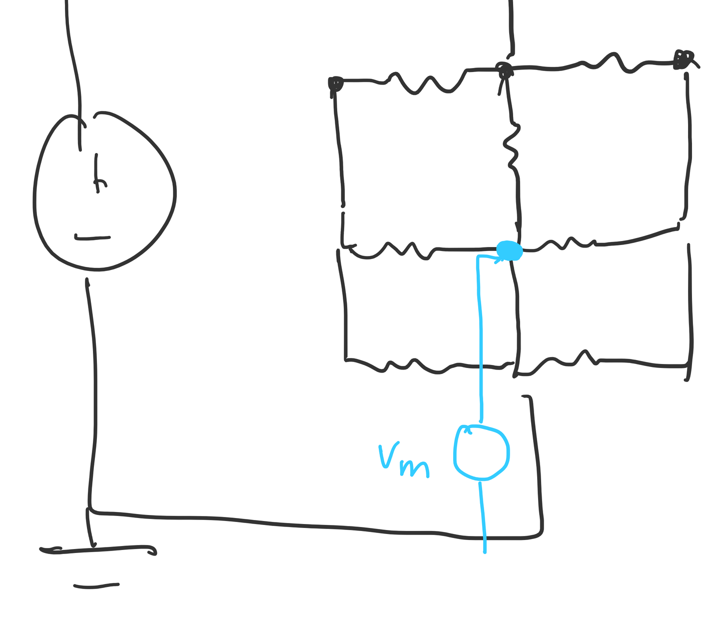


Top layer connected to V_s (bottom connected to voltmeter)



Bottom layer connected to V_s:





Both top and bottom layers connected to V_s → not possible to measure vertical & horizontal position at the same time

When top layer is connected to V_s & bottom layer is connected to a voltmeter

→ measures vertical position

When bottom layer is connected to V_s & top layer is connected to a voltmeter

→ measures horizontal position