EE16A: Touch Screen Technology

Note Packet 2

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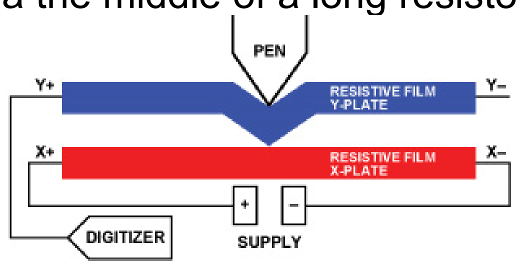
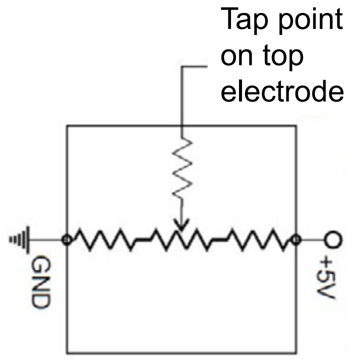
How does this relate to touch screens?

- When we press at some point on the screen, we “tap” into a the middle of a long resistor



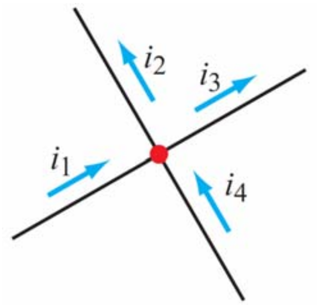
- We can model this as a top on a series connection of lots of resistors.
- We need to determine the voltage on the tap point and use this for position determination



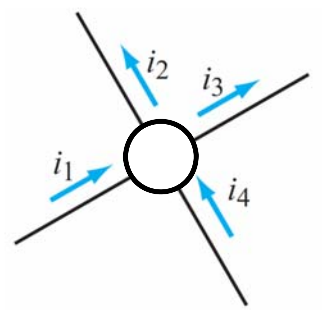
1^{st} design tool: Kirchhoff's Current Law (KCL)

Sum of currents entering a node is zero
Also holds for closed boundary

$$\sum_{n=1}^{N} i_n = 0 \qquad \text{(KCL)},$$



$$i_1 - i_2 - i_3 + i_4 = 0$$
$$i_1 + i_4 = i_2 + i_3$$



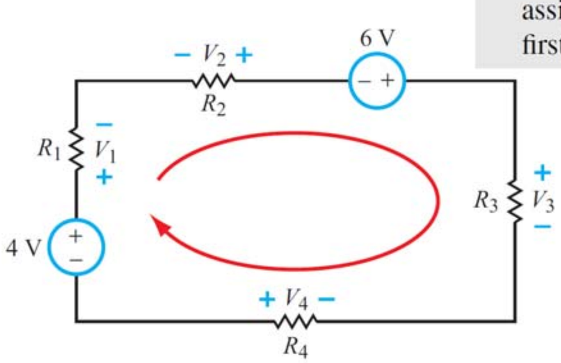
2^{nd} Design tool: Kirchhoff's Voltage Law (KVL)

Sum of voltages around a closed path is zero
Sum of voltage drops = sum of voltage rises

$$\sum_{n=1}^{N} v_n = 0 \qquad \text{(KVL)},$$

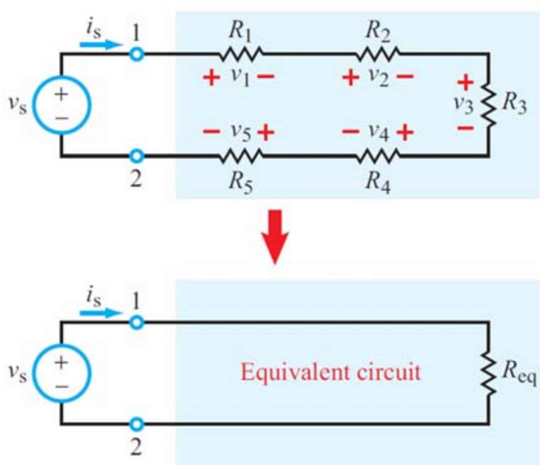
Sign Convention

- Add up the voltages in a systematic clockwise movement around the loop.
- Assign a positive sign to the voltage across an element if the (+) side of that voltage is encountered first, and assign a negative sign if the (−) side is encountered first.



$$-4 + V_1 - V_2 - 6 + V_3 - V_4 = 0$$

Combining Resistors – Series



For equivalence, currents and voltages must be the same

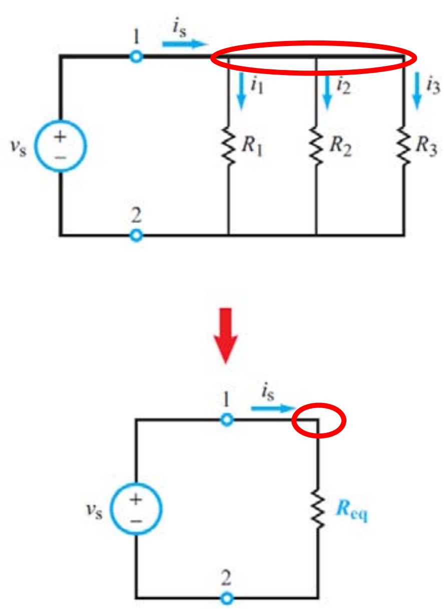
- Do a KVL:

<u>Top Circuit</u>

<u>Bottom Circuit</u>

<u>Equating</u>:

Combining Resistors - Parallel



- Do a KCL

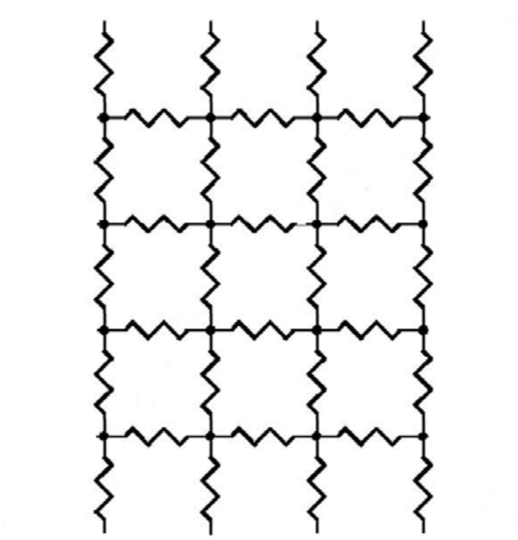
- In other words:

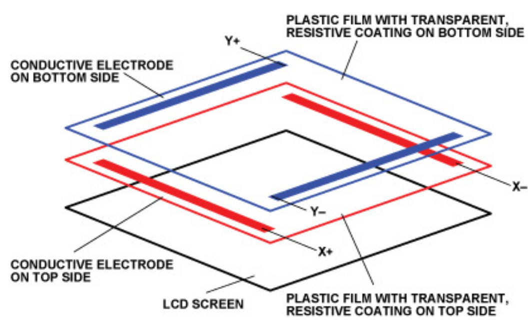
- More generally:

Useful Videos

- KVL and KCL: http://youtu.be/MlwYUBe16C0

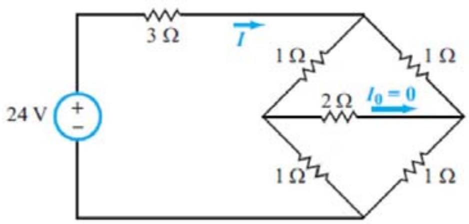
Going back to that touch screen…



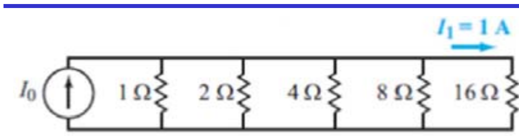


If the stripes are very conductive, does the voltage vary laterally?

Exercise: Find I

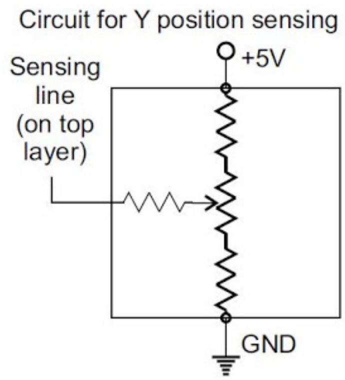


Exercise: Find I_0

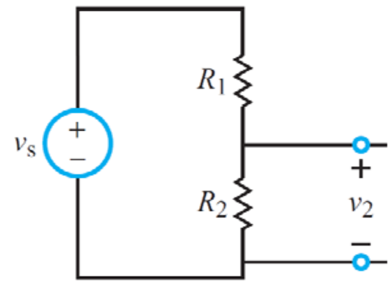


Going back to that touch screen…

- The "tapped" electrode line is called a voltage divider



For now, let's ignore the resistor on the tap and simplify / generalize to:

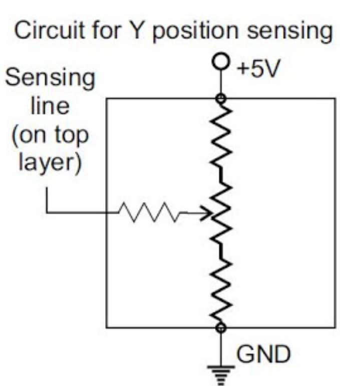


- Let's try a KVL:

So we've found the voltage.
Now to relate this to position….

What about that assumption?

- We just assumed



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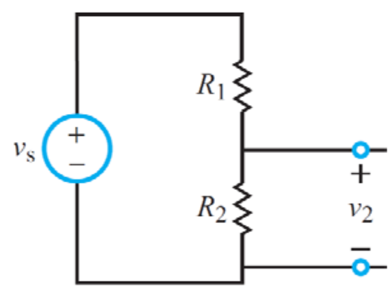
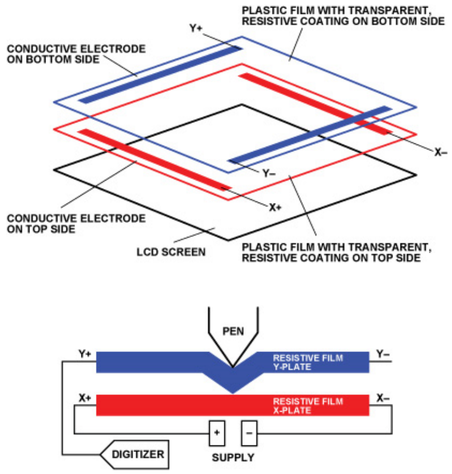


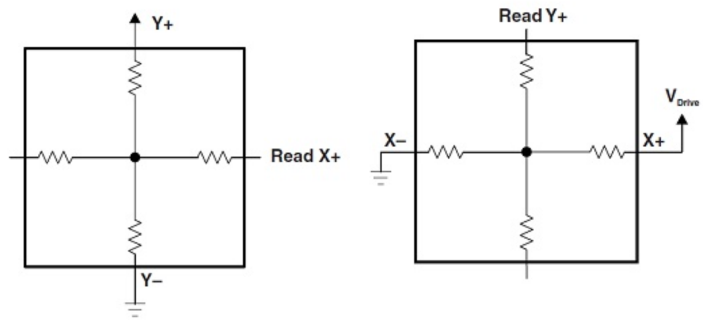
- What does this say about the voltage sensing circuitry?

Position determination

- A touch screen system drives the top and detects on the bottom, and vice versa to find X and Y positions

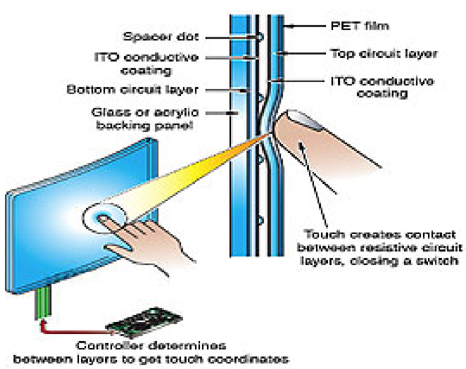


$$y = \frac{V_{X+}}{V_{Drive}} \times \text{height}_{screen} \qquad x = \frac{V_{Y+}}{V_{Drive}} \times \text{width}_{screen}$$



- Problems:
  - Requires "hard" contact
  - Cannot do multi-touch, since only one voltage is measured on the sensing plate

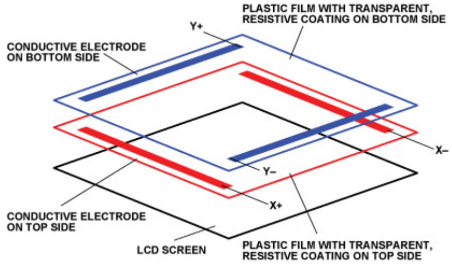
Exercise: Calculate voltages sensed

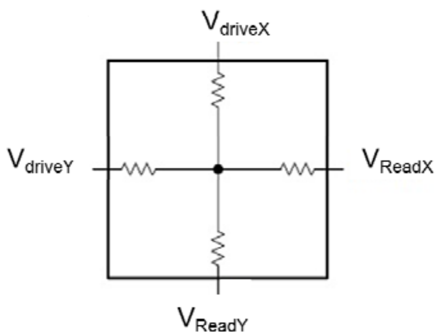


- Assume
  - Resistance is 1kΩ/cm of electrode line
  - Screen is 40cm $\times$ 30cm
  - $V_{applied}$ = 5V
- What is V_x,V_y for touch at:
  - Center of screen
  - Center of top-left quadrant

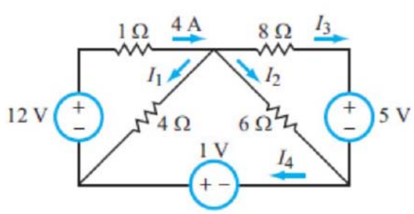
Exercise: Simultaneous X, Y determination

- Suppose I were to try to apply voltages on both layers to try to determine X and Y in one measurement, would this work?



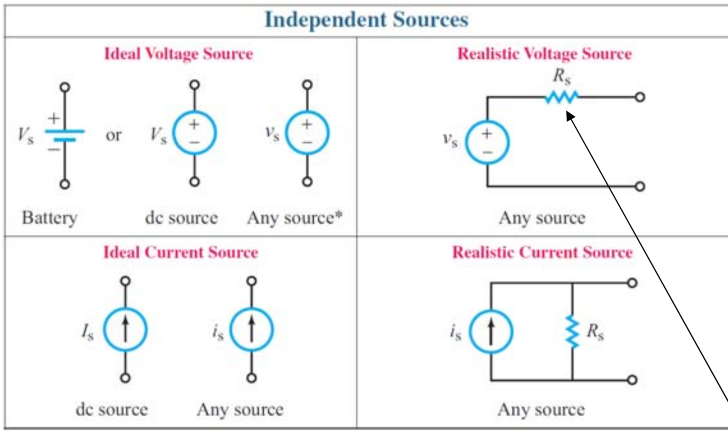


Exercise: Find I_1, I_2, I_3, I_4



Independent Sources

- We can achieve multi-touch if we drive with a current rather than a voltage.
- In general, we can define independent sources as:

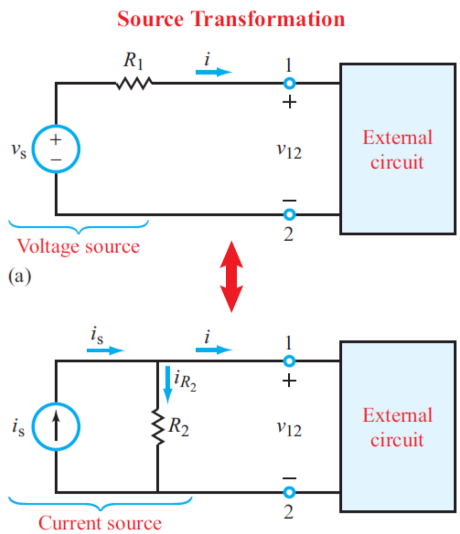


The resistance represents the fact that realistic sources "droop" when the load is increased (for example, car headlights often dim as you crank the engine to start

Exercise: Realistic voltage source

- When I turn on my car headlights, my effective voltage of the 12V battery drops to 11.5V. What is the internal resistance of the battery?
  - Assume the bulb wattage is 50W per bulb

Exercise: Convert from V_s to I_s



Useful Videos

- Transformations: http://youtu.be/6Ujq1SeLhU8
- Nodal: http://youtu.be/RgR232M16bE
- Mesh:http://youtu.be/yzJI-KufYNg
- Inspection: http://youtu.be/Dfrn7AI-AuY
- Linearity and Superposition: http://youtu.be/ky0cfK-HQEA
- Equivalence: http://youtu.be/hNsZJKowd34
- Equivalence Examples: http://youtu.be/Ne-KPt4IFp4