EECS 16A Touchscreen 3A

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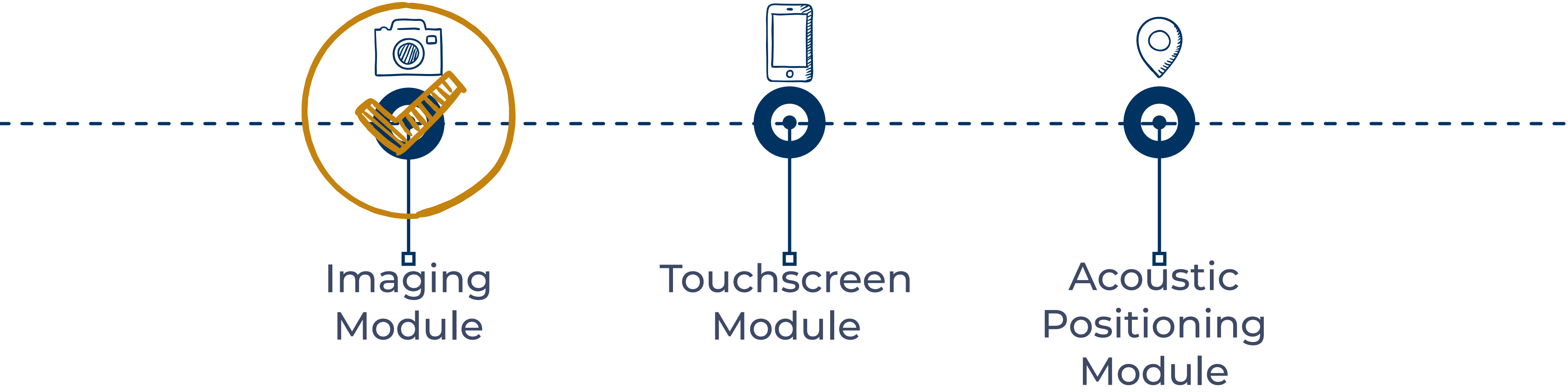
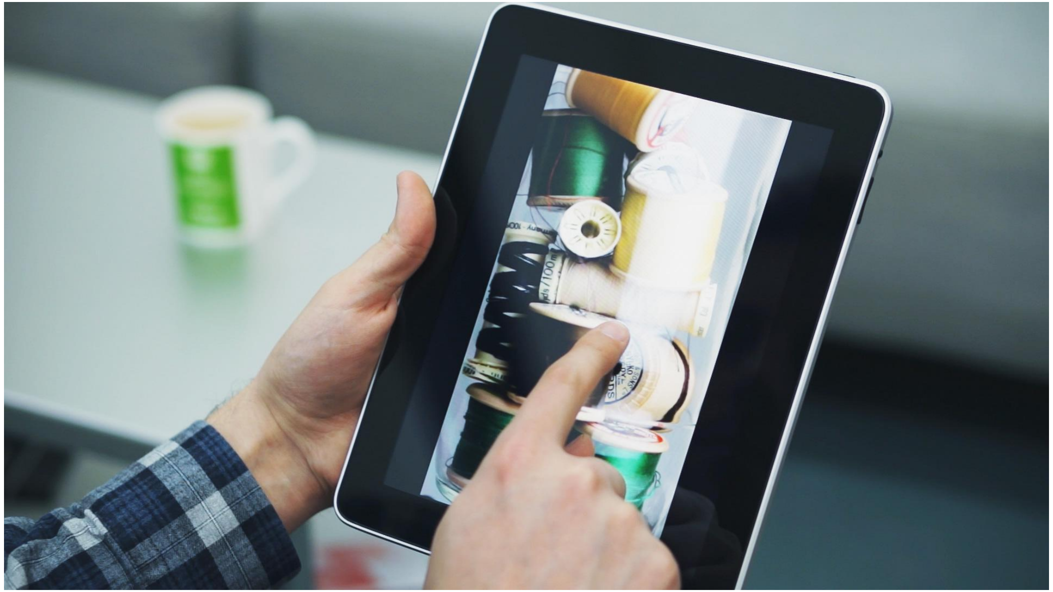
Semester Outline



Last Time

- Resistive touchscreen
  - Use voltages as signals
  - Two voltage dividers perpendicular to each other
- Why are resistive touchscreens obsolete?
  - Single touch only
  - Moving parts and complicated structure

This Week: Capacitive Touchscreens

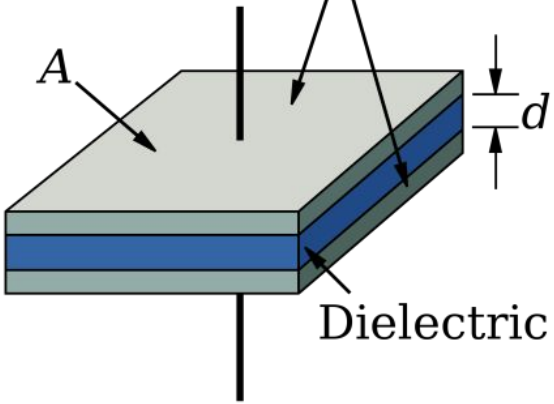


This Week: Capacitive Touchscreen

- Today: capacitive touchscreens
  - Exploits capacitive properties of finger/body
  - Touching the screen chances the capacitance
- Much better than resistive!
  - No moving parts
  - Multi-touch is possible
  - More sensitive
- How to measure capacitance?

Capacitance and the touchpad

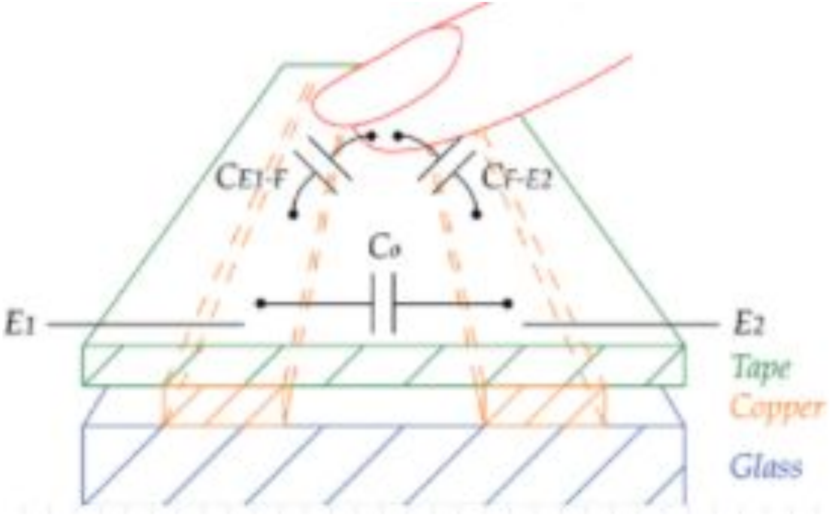
$$C = \frac{\epsilon_0 A}{d}$$



Touching Changes Capacitance

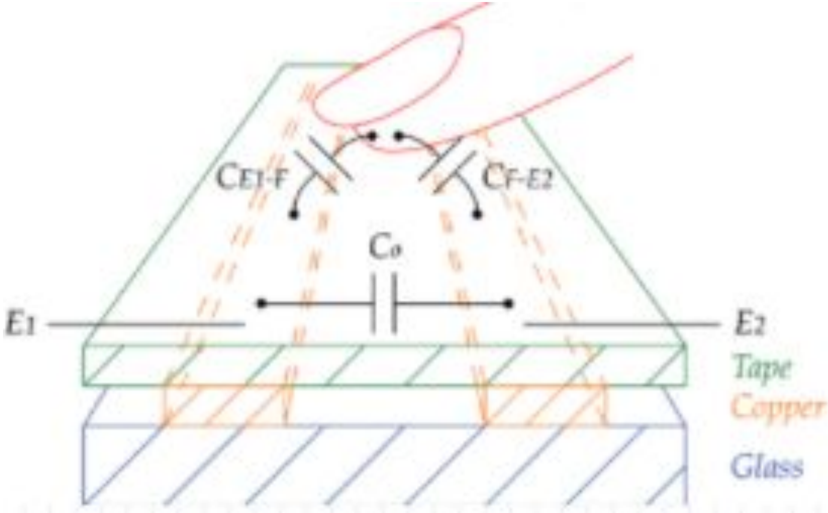
- Screen = some capacitance
- Screen + finger = different capacitance

How do we detect this change in capacitance?



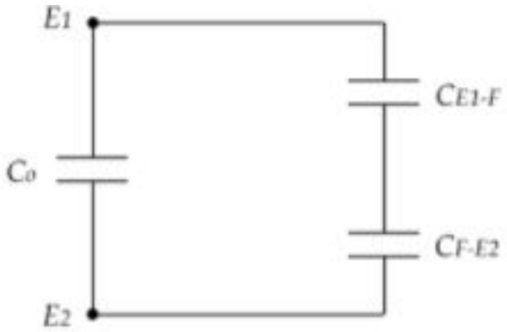
Effect of Touch on System

- How does a touch affect the capacitance?



$$C_{series} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_n}}$$

$$C_{parallel} = C_1 + C_2 + \ldots C_n$$



Capacitors and Current

- Note that if current is constant, voltage is just linear with time
  - Integrate to get an expression
- Having a linear voltage signal is easy for us to read!

$$I = C\frac{dV}{dt}$$

Finding V(t)

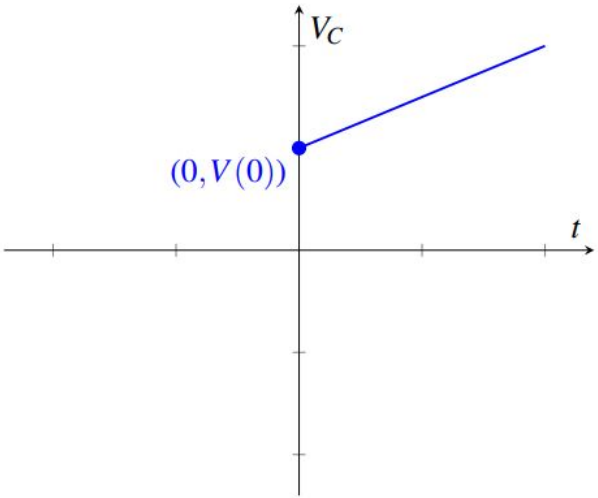
$$I = C\frac{dV}{dt}$$

$$\frac{dV}{dt} = \frac{I}{C}$$

$$\int_0^t dV = \int_0^t \frac{I}{C}\,dt$$

$$V(t) - V(0) = \frac{I}{C}t$$

$$V(t) = \frac{I}{C}t + V(0)$$



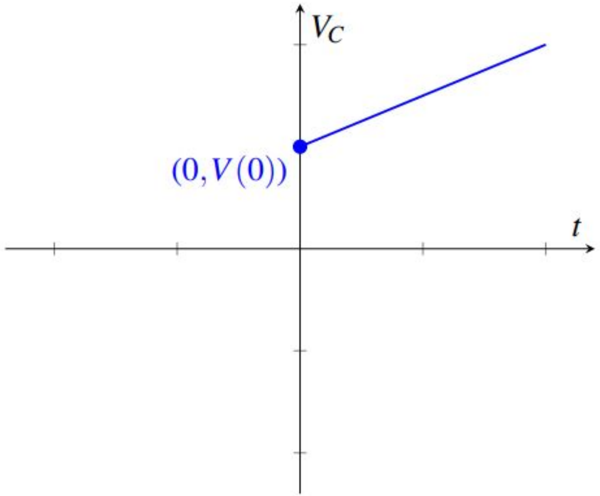
- Voltage increases with time!
- Note: we're assuming constant I
- **What's the slope of this line?**

Effect of Touch on System

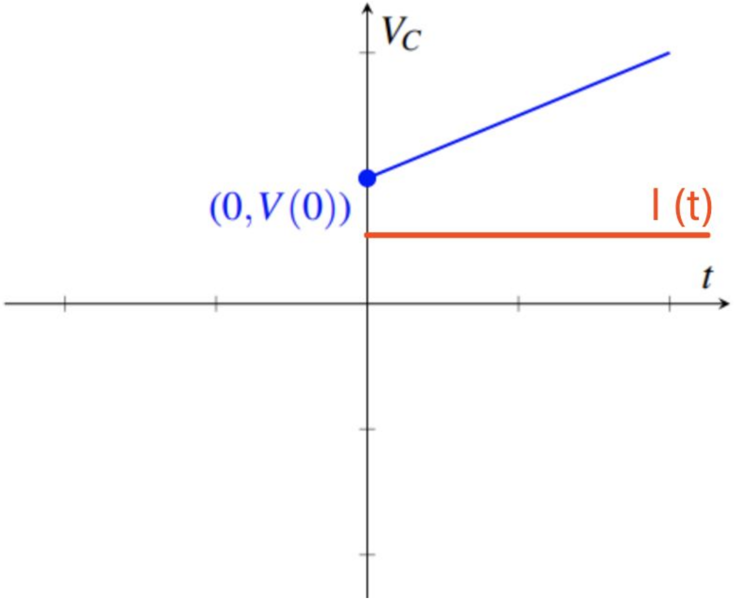
- Touch introduces capacitance, so C increases
- How does touch affect our voltage waveform?

$$V(t) = \frac{I}{C}t - V_0$$

- **What happens to the slope?**



Issues with the Model



Issues with the Model

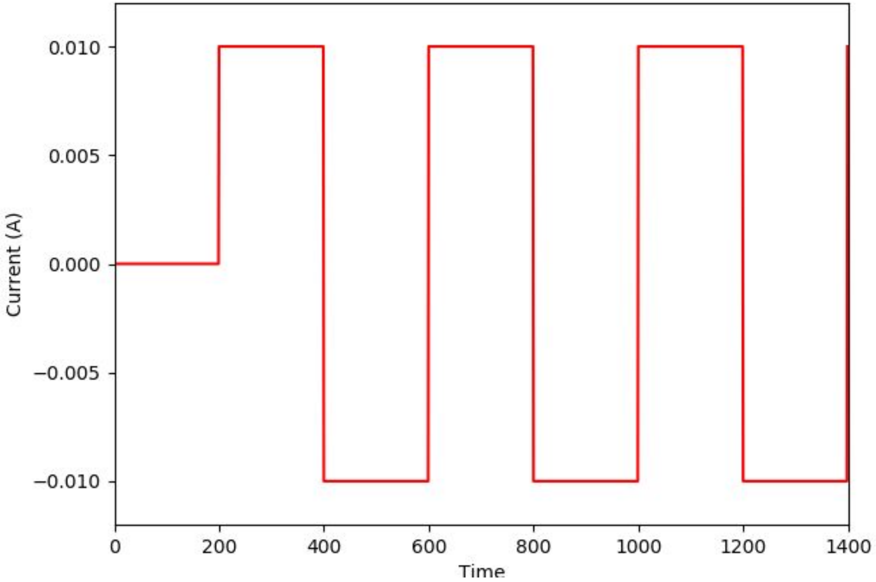
- How high can V(t) get?
  - In theory: infinity. In practice: not quite, but still too high.
- We need to discharge it to make its usage practical
  - Periodically apply negative current

$$V(t) = \frac{I}{C}t + V(0) \quad \rightarrow \quad V(t) = -\frac{I}{C}t + V(0)$$

- Two different slopes!
- **What's the shape of the applied current?**

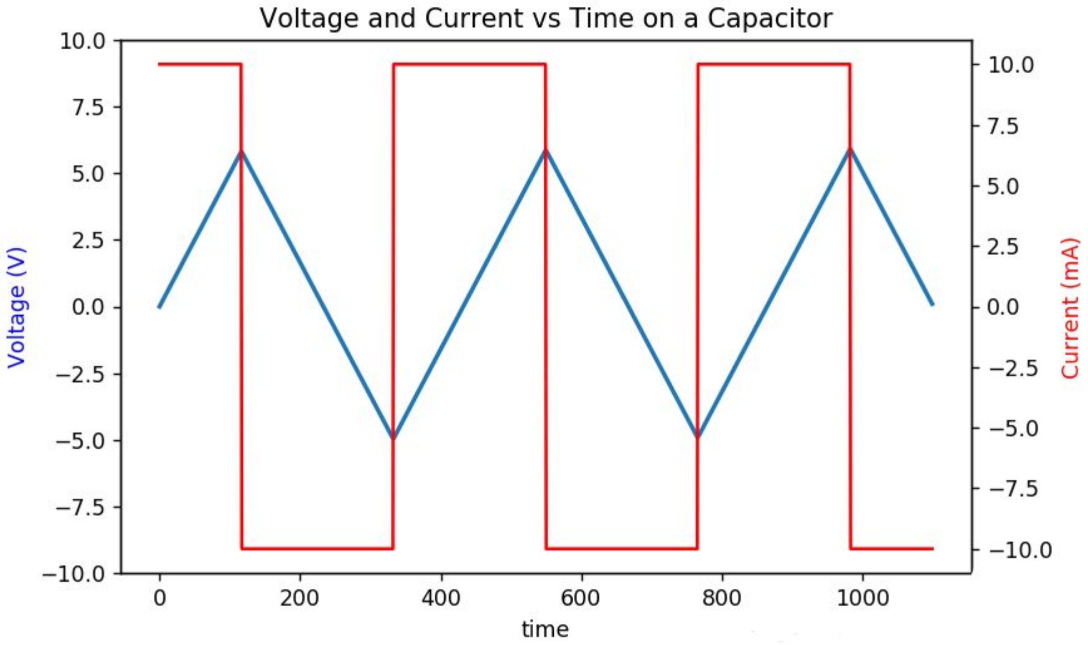
Square Wave Current Source

- Square waves only have two values: high and low
- Use this to charge + discharge the capacitor
- High: +10mA
- Low: -10mA
- Note: We have 0mA in the beginning to set initial condition



Triangle Wave Voltage Reading

$$V(t) = \frac{I}{C}t + V(0)$$



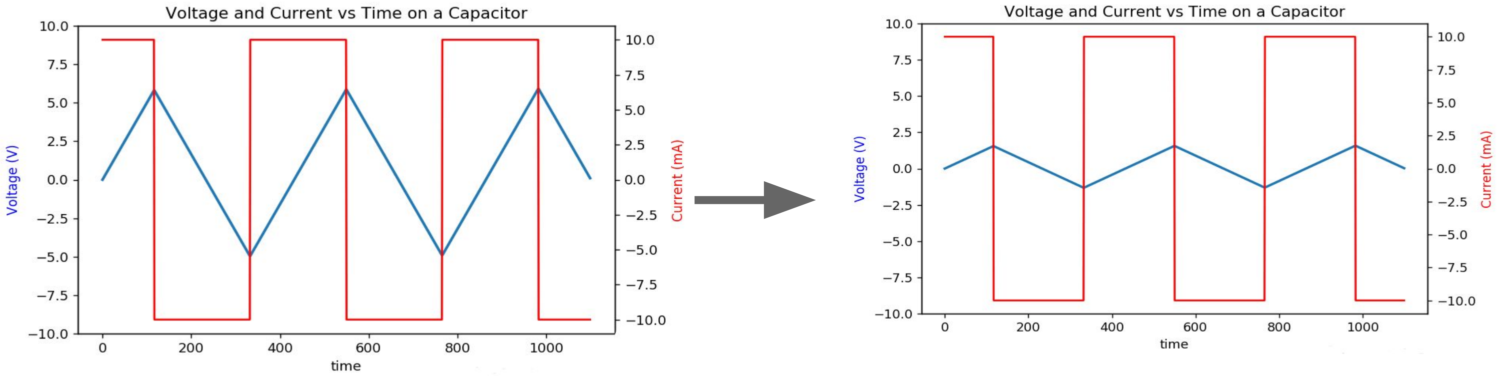
Note: V(0) = 0 in this plot

Measuring Capacitance Changes

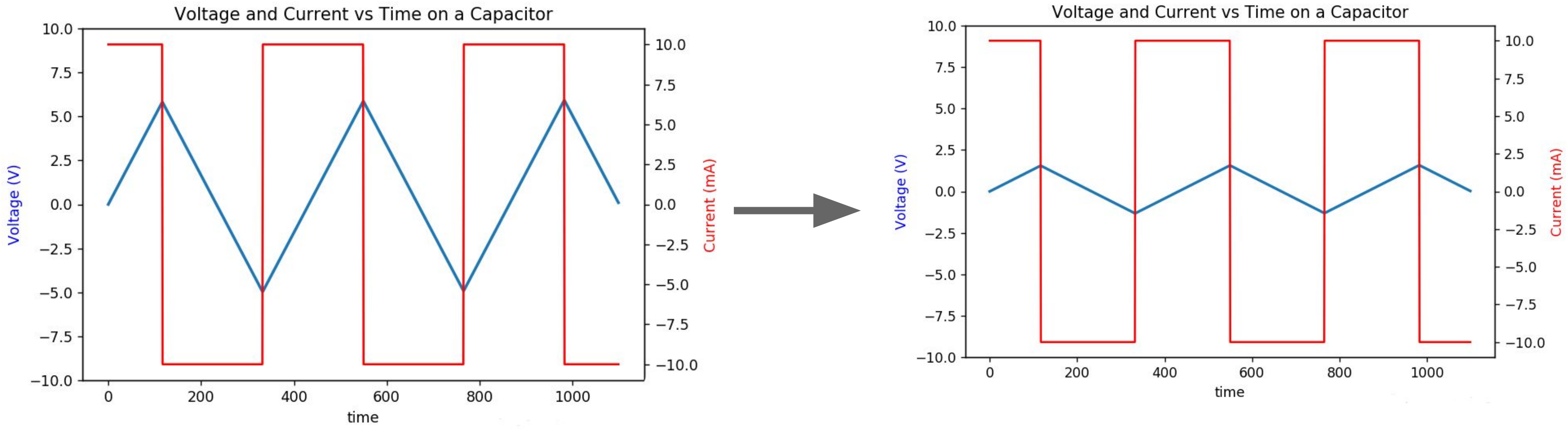
- Capacitance isn’t easy to directly measure, but we’ve mapped our capacitance into our voltage waveform
  - Current can be difficult to measure directly
  - Changes in voltage are easy to see

Difference in Peak Voltages

- To determine changes in capacitance, we can compare the peaks to some reference voltage
  - Higher peak: no touch
  - Lower peak: touch



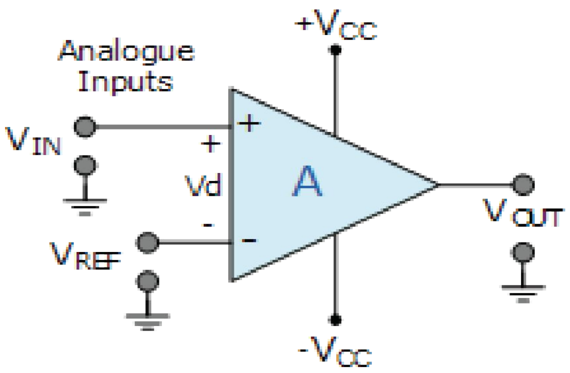
Detecting Touch



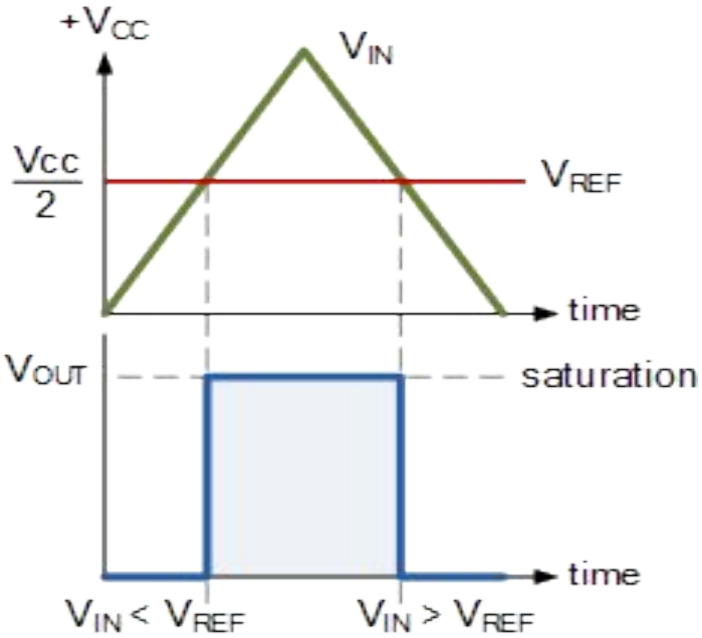
- How do we detect this?
    - **What do we need to compare between these two waveforms?**

Comparators

- Compares input voltage at positive terminal to a reference voltage at negative terminal



If $V_{IN} > V_{REF}$ then $V_{OUT} = +V_{CC}$
If $V_{IN} < V_{REF}$ then $V_{OUT} = -V_{CC}$



Completing Actuation

- Use comparator to visualize difference
- We use an LED to visualize actuation
- Two outputs:
  - Touch: -5V
  - No touch: square wave
- LED will turn on if the voltage across it is high enough!

Notes

- Materials: 2 copper strips, glass slide, tape, solder
- Be sparing on tape and solder usage
- Remember to remove the backing of copper strips (they're adhesive)
- Make sure the copper strips span the length of the glass slide