
EECS 16A Touchscreen 3A

****Insert your names here****

Semester Outline



Imaging
Module



Touchscreen
Module



Acoustic
Positioning
Module

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

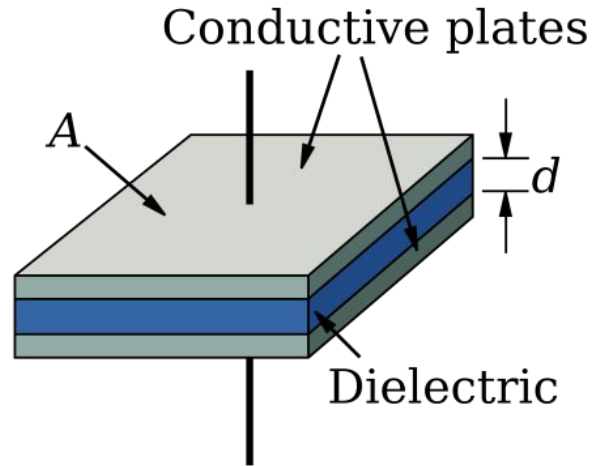


This Week: Capacitive Touchscreen

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

Capacitance and the touchpad

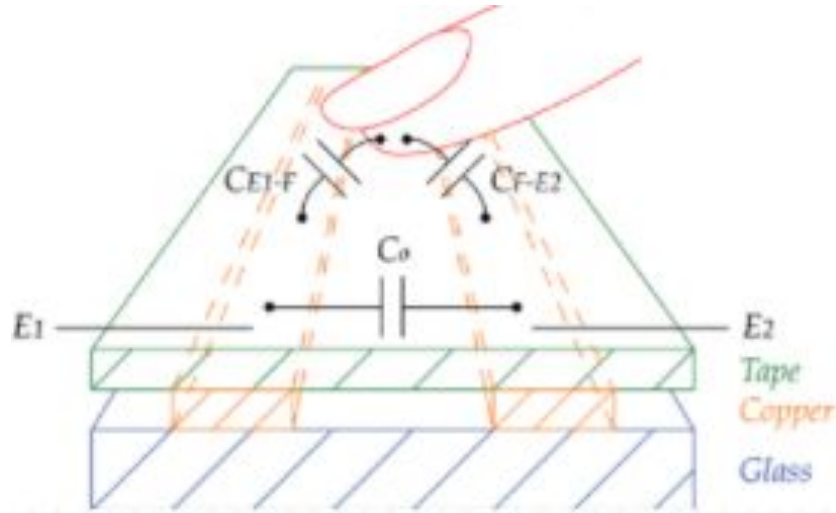
$$C = \frac{\epsilon_0 A}{d}$$



Touching Changes Capacitance

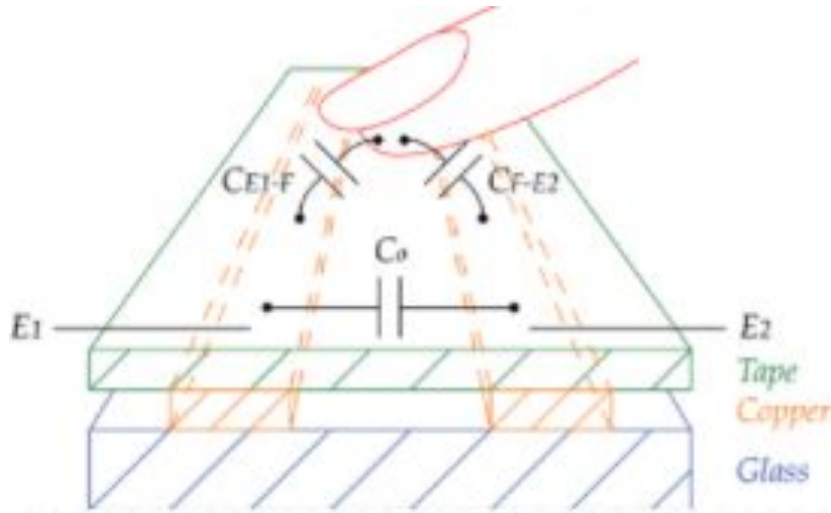
- Screen = some capacitance
- Screen + finger = different capacitance

How do we detect this change in capacitance?



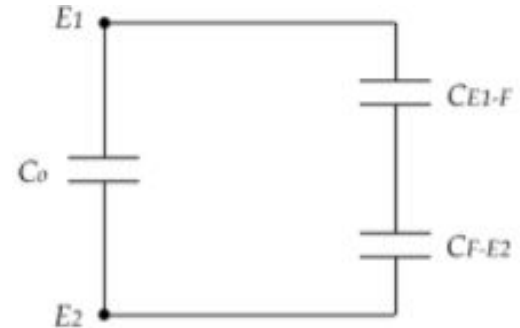
Effect of Touch on System

- How does a touch affect the capacitance?



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

$$C_{\text{parallel}} = C_1 + C_2 + \dots + C_n$$



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 $V(t)$

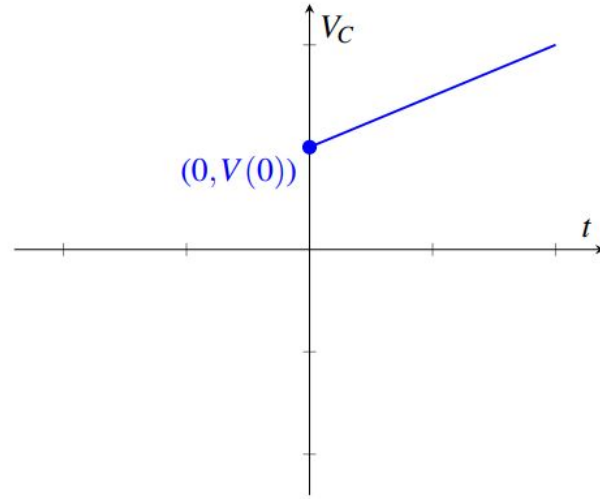
$$I = C \frac{dV}{dt}$$

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

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

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

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



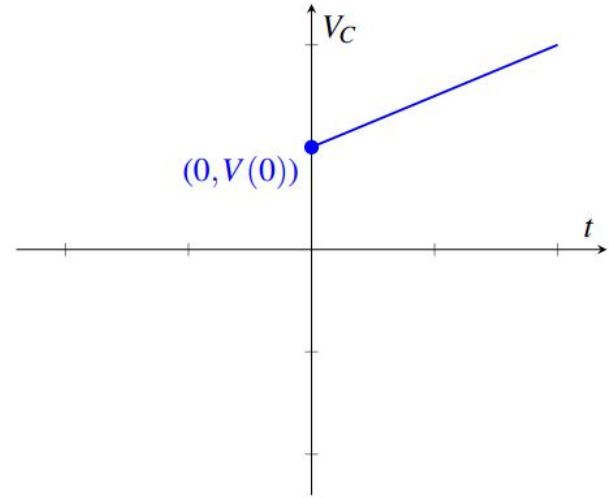
- Voltage increases with time!
- Note: we're assuming constant I
- **What's the slope of this line?**

Effect of Touch on System

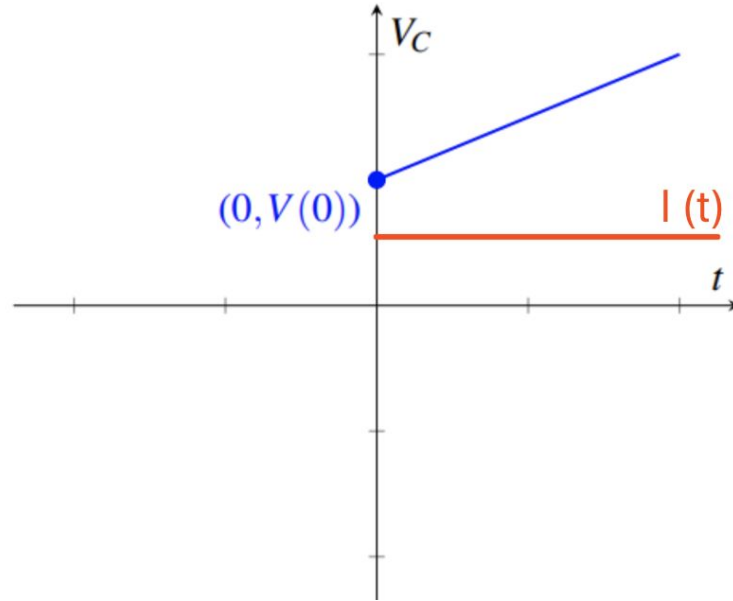
- Touch introduces capacitance, so C increases
- How does touch affect our voltage waveform?

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

- **What happens to the slope?**



Issues with the Model



Issues with the Model

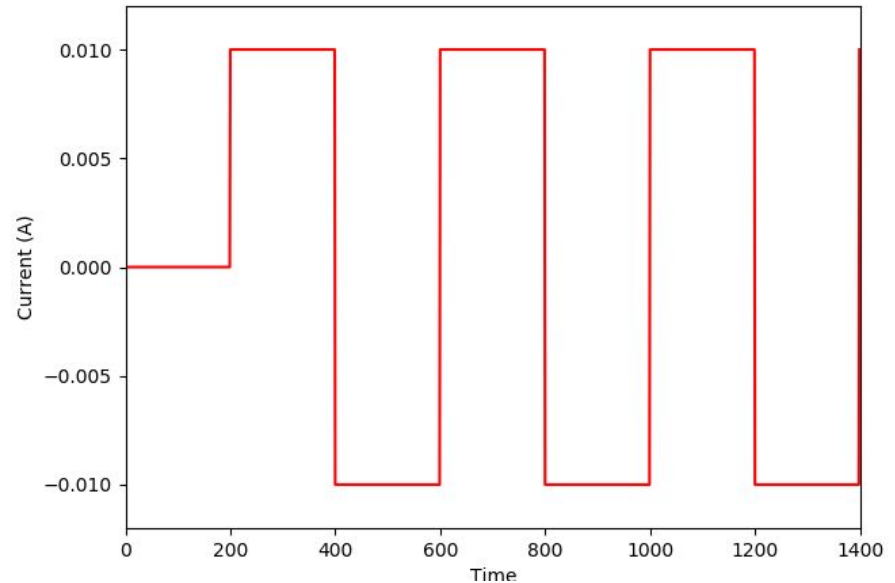
- How high can $V(t)$ get?
 - In theory: infinity. In practice: not quite, but still too high.
- We need to discharge it to make its usage practical
 - Periodically apply negative current

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

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

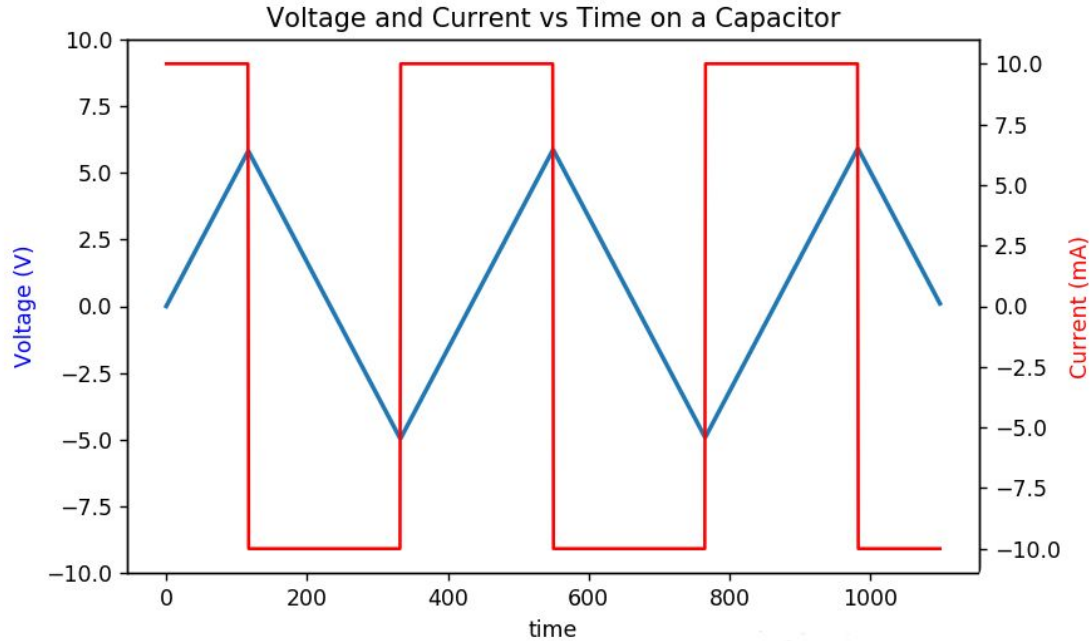
Square Wave Current Source

- 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

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



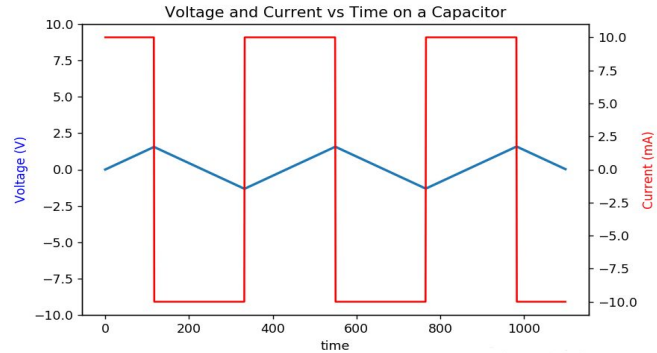
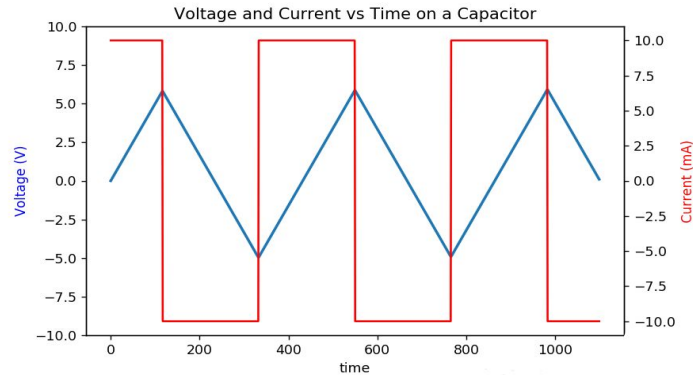
Note: $V(0) = 0$ in this plot

Measuring Capacitance Changes

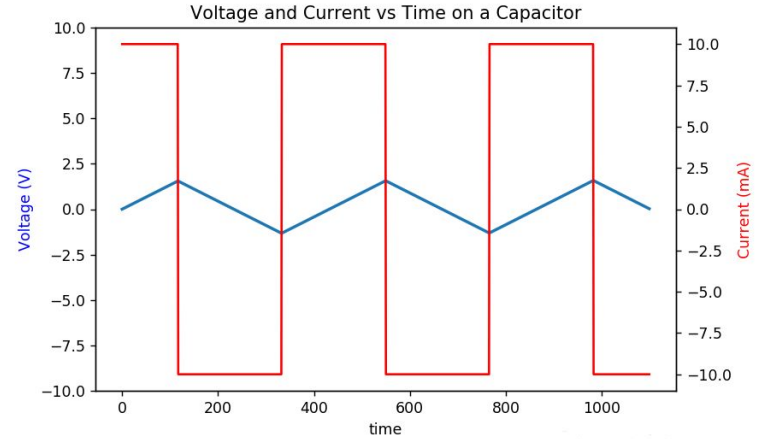
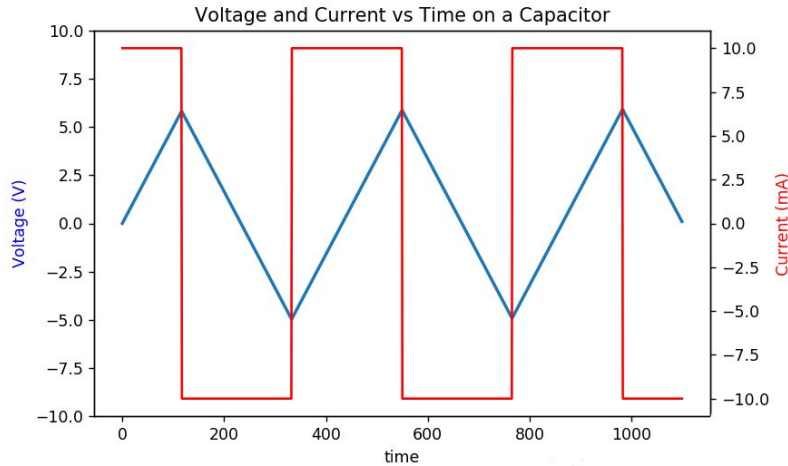
- Capacitance isn't easy to directly measure, but we've mapped our capacitance into our voltage waveform
 - Current can be difficult to measure directly
 - Changes in voltage are easy to see

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



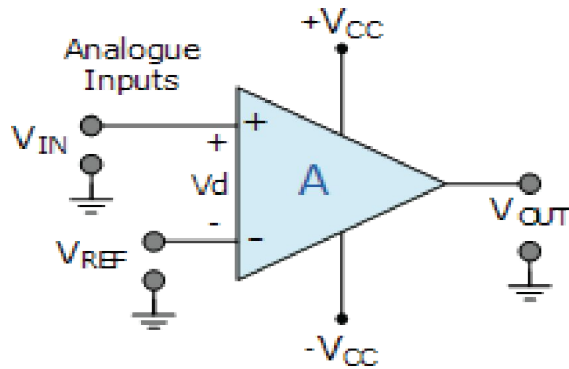
Detecting Touch



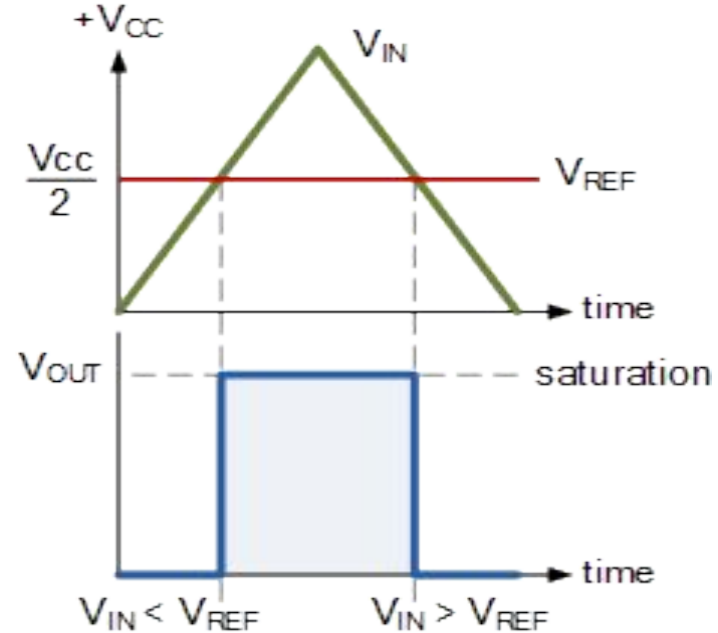
- How do we detect this?
 - **What do we need to compare between these two waveforms?**

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
- Please take a moment to fill up this survey!
 - <http://tiny.cc/labfb>