
EECS 16A Designing Information Devices and Systems I

Fall 2022 Touch 3A Pre-Lab Reading

1 Touch 2 Review

In the last lab, you built your first touchscreen! You used voltage dividers to measure voltages at different touch-points. You used these unique voltage measurements to determine the exact coordinates of your touch. What are some issues with the resistive touchscreen? They are single touch only and require moving parts with a complex resistive mesh. To mitigate these issues, we will look at a different kind of touchscreen – the capacitive touchscreen!

2 Touch 3 Preview

A capacitive touchscreen is a touchscreen that is commonly used today. All your phones and tablets have touchscreens that work on the basic principles of capacitive touchscreens. It is composed of a glass-like transparent layer, strips of metal that act as the plate of the capacitor and another transparent, conductive layer at the top. Real-world touchscreens have many other layers such as flexible surfaces and LCD display layers. The capacitive touchscreen, as the name suggests, exploits the capacitive properties of our fingers/body. It works on the simple principle that touching the screen induces a change in capacitance due to the addition of our finger(s). If we can find a way to detect this change in capacitance, we can detect a touch!

2.1 Capacitors

Before we look at the touchscreen, let's look at the component we use to build it - the capacitor! A capacitor is a circuit element that stores charge. It has 2 metallic plates with something called a dielectric material in between the plates. When a voltage is applied, current going through the capacitor gets obstructed by the dielectric material. This allows positive charge to collect on one plate and negative charge to collect on the other. The capacitance (C) of a capacitor is given by the relation $C = \frac{\epsilon A}{d}$.

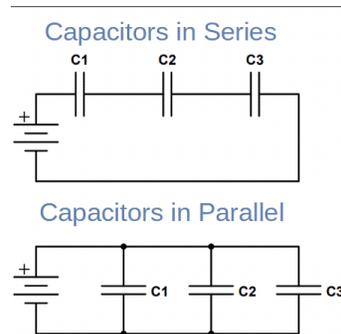
2.2 Current-Voltage Relation for Capacitors

Recall that the relation between voltage and current for a resistor is given by $V = IR$. Is there a similar relationship for capacitors? Yes! It is not as straightforward as $V = IC$. The relationship is derived as follows.

The charge, voltage and capacitance of a capacitor are related by the equation: $Q = CV$. The derivation for this requires physics concepts beyond the scope of this class so take this as fact for now! The definition of current is the amount of charge per unit time. Mathematically, we can define this as $I = \frac{dQ}{dt}$. Plugging in for $Q = CV$, we get $I = \frac{d}{dt}CV = C\frac{dV}{dt}$ (since C is a constant). We can thus find the voltage with respect to time as $V(t)$ by integrating both sides of the previous equation.

2.3 Capacitors in Series and Parallel

Just like resistors, capacitors can be connected to each other in series and parallel configurations. However, the equivalence relations are not the same.

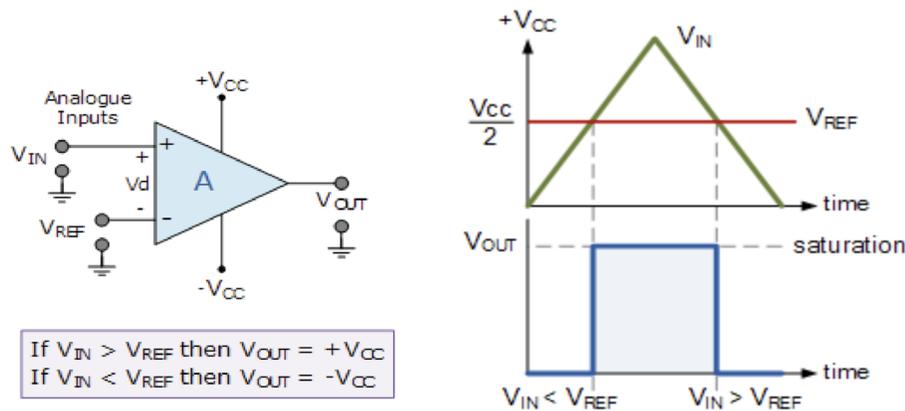


For series, $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$

For parallel, $C_{eq} = C_1 + C_2 + \dots + C_n$

2.4 Op-Amps

An op-amp (operational amplifier) is a device that transforms a small voltage difference into a very large voltage difference [Note 17]. An op-amp can be used as a comparator – something that compares two voltages and indicates which is larger. A comparator is a helpful logical circuit element since it only has two possible outputs. This helps us since we want to model our touchscreen as a 'binary' system with outputs - 'Touch' and 'No Touch'. Here's an op-amp being used as a comparator:



Earlier, we saw a way to relate voltage to the capacitance. We also saw that touching the touchscreen causes a change in capacitance due to the addition of our finger(s). Thus, there will be a change in voltage. If we can determine a suitable V_{REF} , we can make use of our comparator to determine if a touch took place. To get you thinking about this, if we had certain voltages for touch and no touch as V_{touch} and $V_{no-touch}$, what V_{REF} value do you think would work best? We will look more closely at this in lab!