CSM 16A Designing Information Devices and Systems I
Fall 2020 Week 8

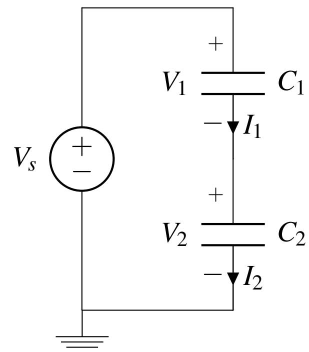
1. **Series and Parallel Capacitors**

   Learning Goal: This problem will help to understand how capacitors in series or parallel combination respond to a voltage source or a current source.

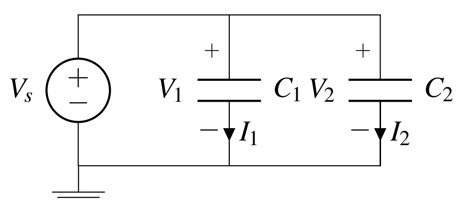
   Relevant Notes: **Note 16: Section 16.3** goes over the capacitance equivalence.

   Find the voltage across and current through each capacitor for each of the following scenarios. Consider all the capacitors to be initially uncharged.

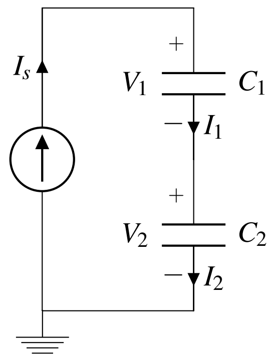
   (a) C_1 and C_2 are in series:



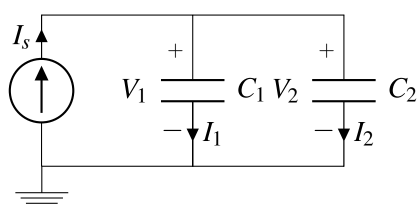
   (b) C_1 and C_2 are in parallel:



(c) C_1 and C_2 are in series:



(d) C_1 and C_2 are in parallel:



2. Capacitive Touchscreen

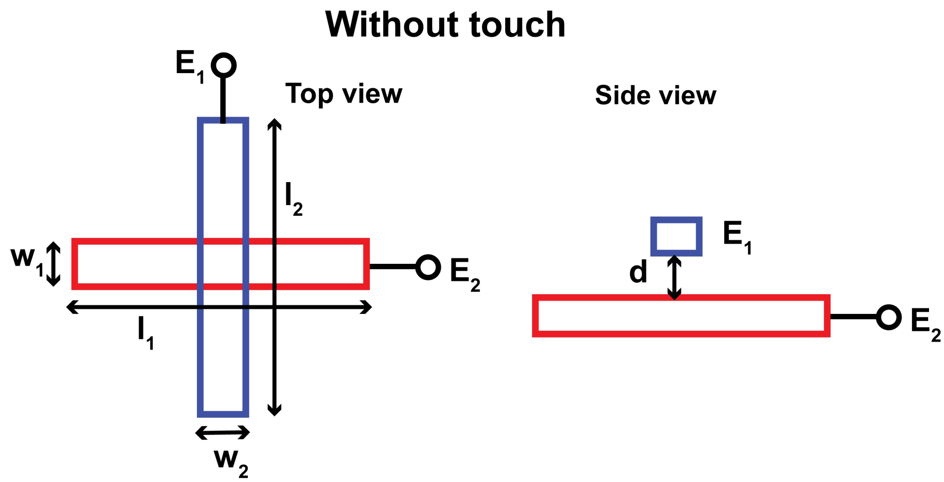
Learning Goal: The goal of this problem is to model the capacitive touchscreen covered in lecture.

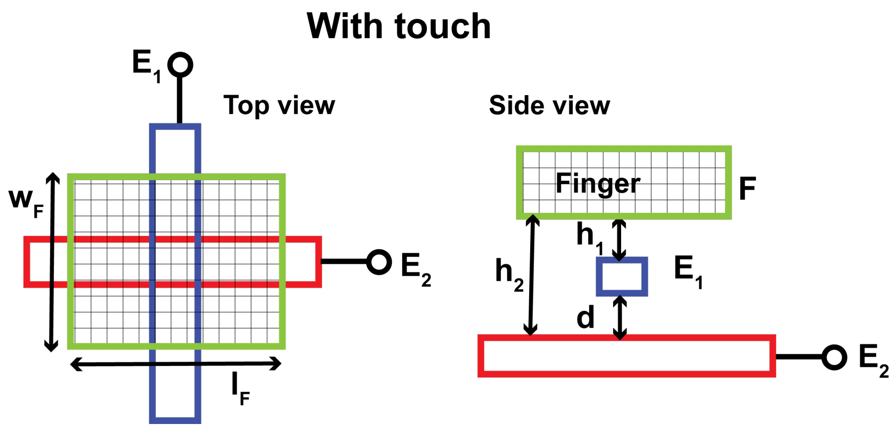
Relevant Notes: **Note 17 Section 17.1** introduces the capacitive touchscreen and its circuit model. **Note 16 Section 16.3** is helpful for creating the model, as it goes over capacitor equivalence.

Consider the following capacitive touchscreen configuration from lecture.

For the following parts, let $\varepsilon = 10^{-11}\text{F/m}$, $w_1 = 1\text{cm}$, $w_2 = 1\text{cm}$,$w_F = 3\text{cm}$, $l_1 = 5\text{cm}$, $l_2 = 5\text{cm}$, $l_F = 4\text{cm}$, $d = 5\text{mm}$, $h_1 = 5\text{mm}$, and $h_2 = 15\text{mm}$.

(a) Draw a diagram representing the capacitance between E_1 and E_2 when there is no touch on the screen.

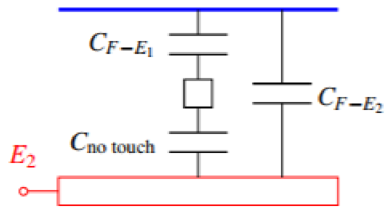




(b) Calculate the value of the capacitance between the two electrodes E_1 and E_2 when the screen is not being touched. Remember that $\varepsilon = 10^{-11}\text{F/m}$, $w_1 = 1\text{cm}$,$w_2 = 1\text{cm}$, and $d = 5\text{mm}$.

(c) Calculate (i) the capacitance between the finger and the top electrodes and (ii) the capacitance between the finger and the bottom electrodes, when the screen is being touched.

(d) Now consider what happens when we touch the screen. Let the blue line represent our finger, and assume there is a capacitance between your finger and each of the electrodes. The diagram looks like this:



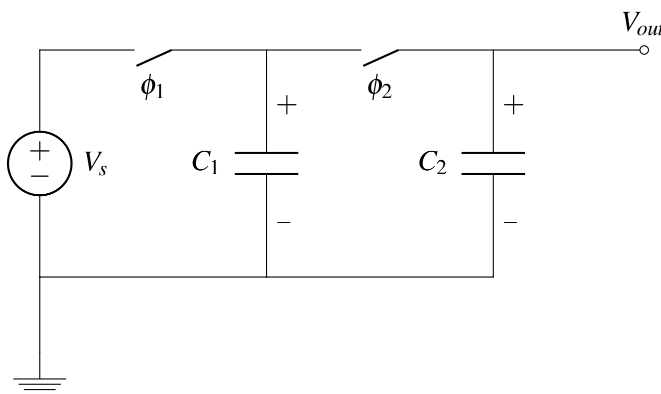
Redraw the circuit diagram representing the capacitive touchscreen after being touched, so that the nodes representing E_1 and E_2 are on opposite ends of the diagram.

(e) Calculate the new capacitance between E_1 and E_2. Remember that $C_{F-E_1} = 6 \times 10^{-13}$F and $C_{F-E_2} = 2 \times 10^{-13}$F. Has the effective capacitance changed from when there was no touch?

3. Charge Sharing and Conservation

In this question, we will explore how charges are conserved and shared when multiple charged (or uncharged) capacitors are connected together. Charge sharing and conservation is useful not only for dividing up the charges for different components (with different power demands) within a system, but also for storing and transferring the power in the case of limited access to the original voltage source.

Given the following circuit containing 2 switches ϕ_1, ϕ_2, the circuit repeatedly goes through a cycle of 2 phases (described below), continuously supplying voltage to the node V_{out}.



The two phases the circuit goes through are as follows:

(i) Close switch ϕ_1 until C_1 (initial uncharged) is fully charged. Switch ϕ_2 remains open.

(ii) Open switch ϕ_1 and close switch ϕ_2. Maintain this configuration until the charges on both capacitors stabilize.

(a) Draw out what the circuit would look like in Phase (i).

(b) Given that C_1 and C_2 are both initially uncharged, what would be the charges Q_1 and Q_2 on capacitors C_1 and C_2 respectively by the end of Phase i? What would V_{out} be?

(c) Draw out what the circuit would look like in Phase (ii).

(d) Continuing from what the charges were on both capacitors at the end of Phase i, what would the charges on both capacitors C_1 and C_2 be by the end of Phase ii? What would V_{out} be?