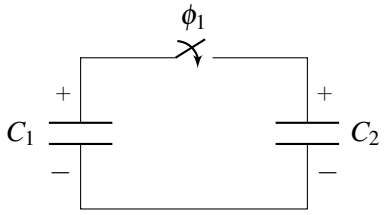
EECS 16A Designing Information Devices and Systems I
Summer 2017 D. Aranki, F. Maksimovic, V. Swamy Discussion 5B

1. Capacitors and Charge Sharing

(a) Consider the circuit below with $C_1 = C_2 = 1\,\mu\text{F}$ and an open switch. Suppose that C_1 is initially charged to $+1\,\text{V}$ and that C_2 is charged to $+2\,\text{V}$. How much charge is on C_1 and C_2? How much energy is stored in each of the capacitors? What is the total stored energy?

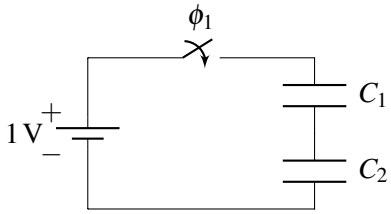


(b) Now the switch is closed (i.e. the capacitors are connected together.) What are the voltages across and the charges on C_1 and C_2? What is the total stored energy?

(c) Is there more or less energy than before the switch was closed? Why?

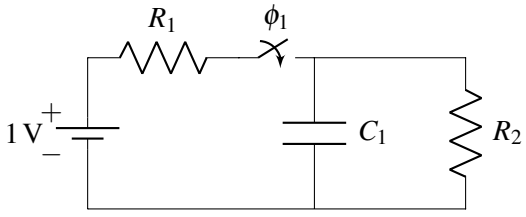
(d) Answer the above three questions but now with $C_1 = 2\,\mu\text{F}$ and $C_2 = 1\,\mu\text{F}$. Suppose that they are initially charged in the same way: C_1 is charged to $+1\,\text{V}$, and C_2 is charged to $+2\,\text{V}$.

(e) Consider the following circuit with $C_1 = 1\,\mu\text{F}$ and $C_2 = 3\,\mu\text{F}$. Suppose that both capacitors are initially uncharged ($0\,\text{V}$).



What are the voltages across each capacitor after the switch is closed? What are the charges on each capacitor?

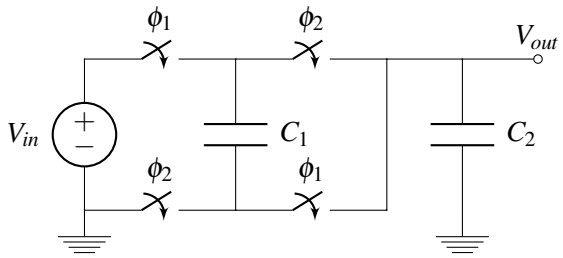
(f) Consider the circuit below with $C_1 = 1\,\mu\text{F}, R_1 = 1\,\text{k}\Omega$, and $R_2 = 1\,\text{k}\Omega$.



After the switch is closed and the circuit is allowed to settle, what is the voltage across and the current through all circuit elements?

2. Charge Sharing

In the circuit shown below, in phase 1, the switches labeled ϕ_1 are on while the switches labeled ϕ_2 are on in phase 2.



(a) Redraw the circuit in phase 1. Label the voltages across each capacitor and find the charge on and voltage across each capacitor as a function of V_{in}, C_1, and C_2. Assume the capacitors are uncharged before phase 1.

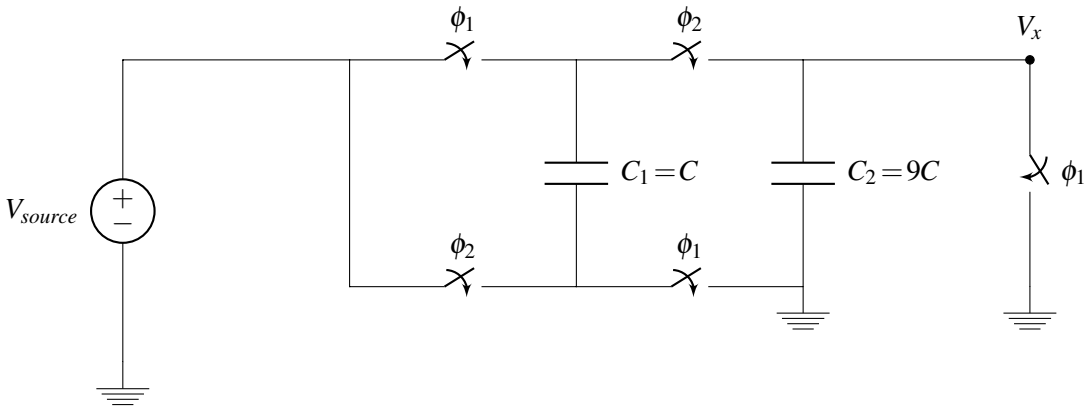
(b) Redraw the circuit in phase 2. Label the voltages across each capacitor and find the charge on and voltage across each capacitor as a function of V_{out}, C_1, and C_2.

(c) Find V_{out} as a function of V_{in}, C_1, and C_2.

(d) How will the charges be distributed in phase 2 if we assume $C_1 \gg C_2$?

3. More Charge Sharing

Consider the following circuit:



In the first phase, all of the switches labeled ϕ_1 will be closed and all switches labeled ϕ_2 will be open. In the second phase, all switches labeled ϕ_1 are opened and all switches labeled ϕ_2 are closed.

(a) Draw the polarity of the voltage (using $+$ and $-$ signs) across the two capacitors C_1 and C_2. (It doesn't matter which terminal you label $+$ or $-$; just remember to keep these consistent through phase 1 and 2!)

(b) Draw the circuit in the first phase and in the second phase. Keep your polarity from part (a) in mind.

(c) Find the voltages and charges on C_1 and C_2 in phase 1. Be sure to keep the polarities of the voltages the same!

(d) Now, in the second phase, find the voltage V_x.

(e) **Practice Problem:** If the capacitor C_2 did not exist (i.e. had a capacitance of 0 F), what would the voltage V_x be?