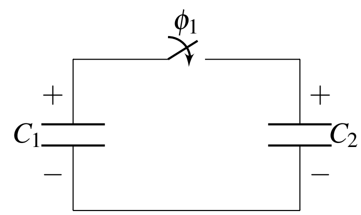
EECS 16A Fall 2019 Designing Information Devices and Systems I

Discussion 9B

1. Capacitors and Charge Conservation (with Energy!)

(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?

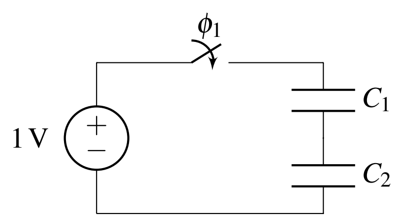


(b) Now the switch is closed (i.e. the capacitors are connected together.) What are the voltages across and the charges on C_1 and C_2? What is the total stored energy?

(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 $+2\,\text{V}$.

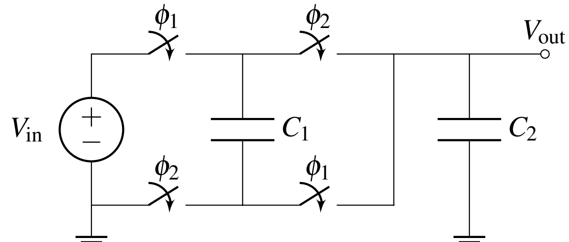
(e) Consider the following circuit with $C_1 = 1\,\mu\text{F}$ and $C_2 = 3\,\mu\text{F}$. Suppose that both capacitors are initially uncharged ($0\,\text{V}$).



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

2. Charge Sharing

Consider the circuit shown below. In phase ϕ_1, the switches labeled ϕ_1 are on while the switches labeled ϕ_2 are off. In phase ϕ_2, the switches labeled ϕ_2 are on while the switches labeled ϕ_1 are off.



(a) Redraw the circuit in phase ϕ_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 ϕ_1.

(b) Redraw the circuit in phase ϕ_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.

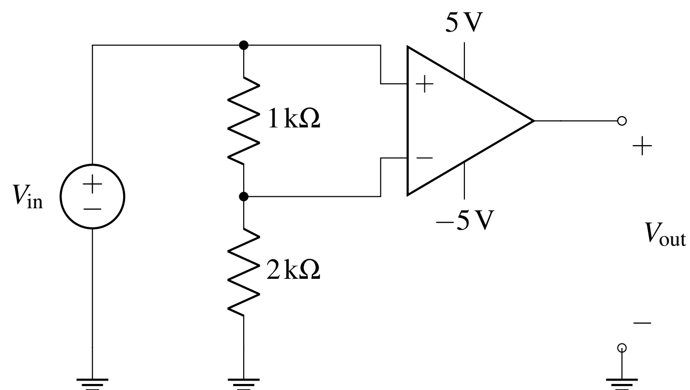
(c) Find V_{out} as a function of V_{in}, C_1, and C_2.

(d) How will the charges be distributed in phase ϕ_2 if we assume $C_1 \gg C_2$?

3. Op-Amps As Comparators

For each of the circuits shown below, plot V_{out} for V_{in} ranging from -10 V to 10 V for part (a) and from 0 V to 10 V for part (b). Let $A = 100$ for your plots. Note that in real op amps, A is typically much higher (i.e. 10^4 – 10^7).

(a)



(b) **[PRACTICE]**