EECS 16A Dis 9A Notes

Tuesday, October 19, 2021 8:12 AM

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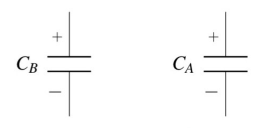
1. Capacitors and Charge Sharing Revisited

(a) Consider two capacitors, C_A and C_B that have been charged to Q_{A_1} and Q_{B_1} repectively. Compute the voltages across each one, V_{A_1} and V_{B_1}.

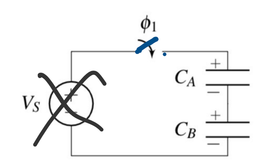
$Q = CV$

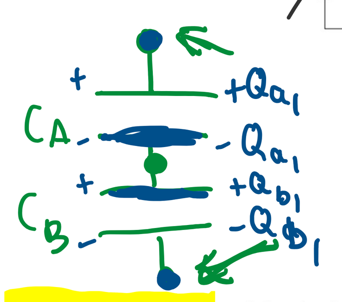


$Q_{A_1} = C_A \cdot V_{A_1}$

$\frac{Q_{B_1}}{C_B} = V_{B_1}$ $\quad \frac{Q_{A_1}}{C_A} = V_{A_1}$

(b) Consider the following circuit set up with an open switch. Given that these were the same charged capacitors as in the previous part, in phase 1, what is the charge and voltage across both capacitors, **before** the switch is closed?

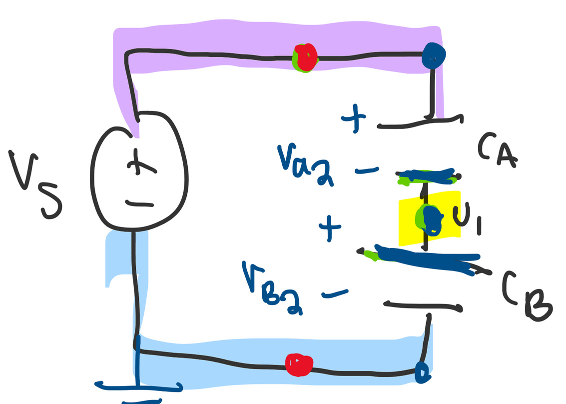




$Q = CV$

$V_{a_1} = \frac{Q_{a_1}}{C_A}$ $\quad V_{B_1} = \frac{Q_{B_1}}{C_B}$

(c) Now the switch is closed, and the circuit is allowed to settle. Compute V_{B_2}, the final voltage drop across C_B, in terms of the given capacitances, the voltages computed in part (a), and V_S.



$Q = CV$

1) $Q_{a_2} = C_A \cdot V_{A_2} = C_A(V_s - u_1)$

2) $Q_{B_2} = C_B \cdot u_1$

$Q_{a_1} = C_A \cdot V_{A_1}$ $\quad Q_{B_1} = C_B \cdot V_{B_1}$

@ u_1: $-Q_{A_2} + Q_{B_2} = -Q_{a_1} + Q_{B_1}$

$Q = CV$

$-[C_A(V_s - u_1)] + C_B \cdot u_1 = -C_A V_{A_1} + C_B V_{B_1}$

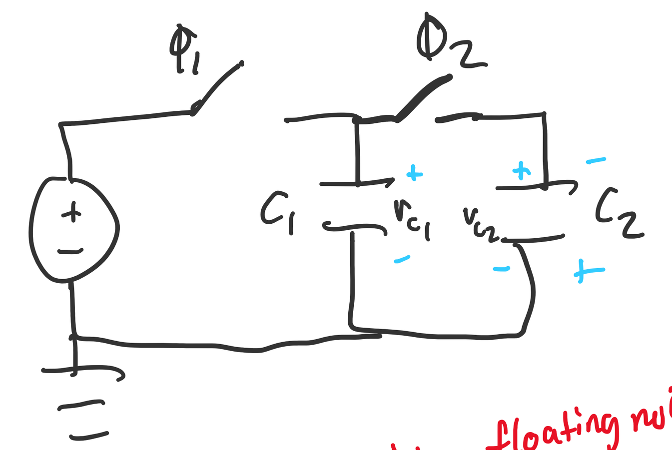
$V_{B_2} = u_1 - 0 = u_1$

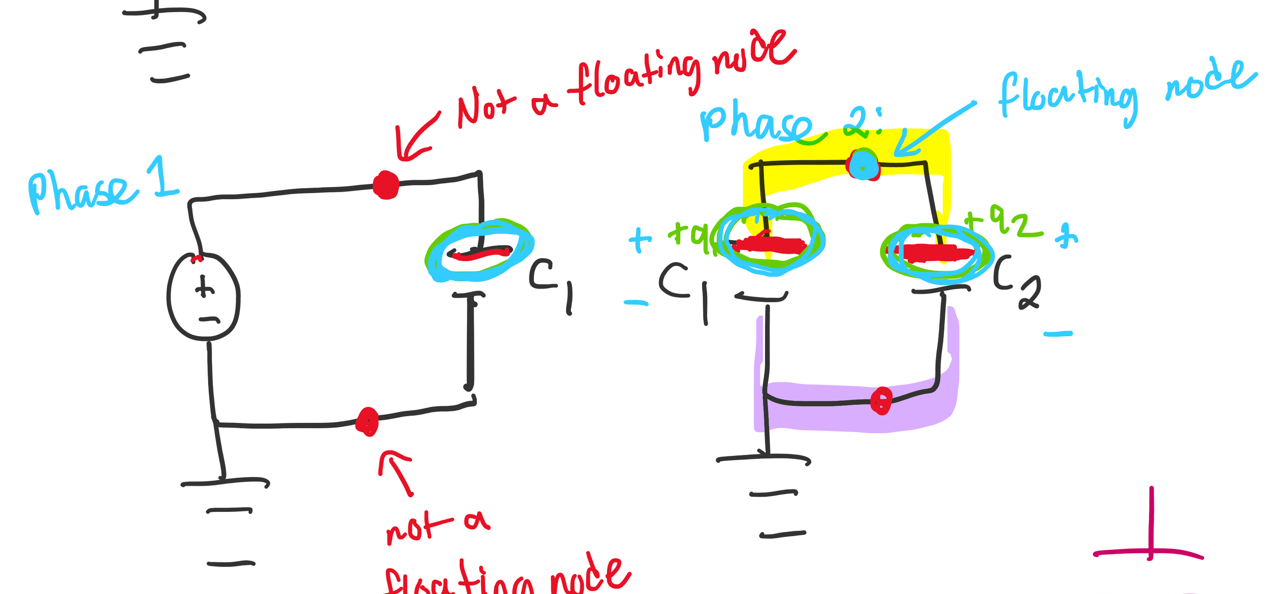
$-C_A V_s + C_A u_1 + C_B u_1 = -C_A V_{A_1} + C_B V_{B_1}$

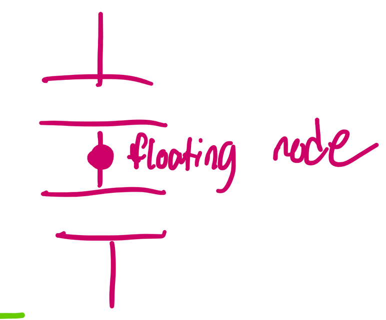
$$u_1 = \frac{-C_A V_{A_1} + C_B V_{B_1} + C_A V_S}{C_A + C_B} = V_{B_2}$$

Charge Sharing Algorithm:

1. Label capacitor voltages and choose polarities to be used for rest of the algorithm
2. Draw circuit for each phase
3. In phase 2, label floating nodes
4. For each floating node, solve for Q^{ϕ_1}
5. Solve for Q^{ϕ_2}
6. Equate $Q^{\phi_1} = Q^{\phi_2}$ due to charge conservation
7. Repeat steps 4-6 for each floating node







Floating node: charge doesn't flow in/out of the node

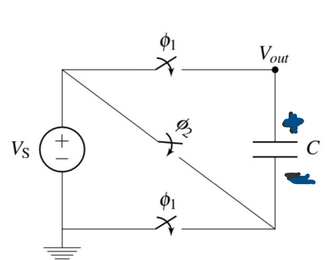
ϕ_2: $Q_{C_1}^{\phi_2} + Q_{C_2}^{\phi_2} = Q_{C_1}^{\phi_1}$

Equate charges on plates in phase 2 from charges on plates during phase 1

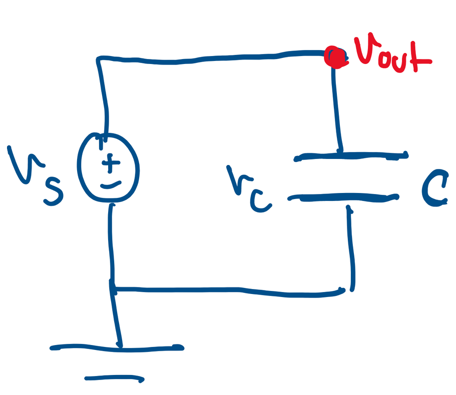
ϕ_2 = phase 2

2. Voltage Booster

We have made extensive use of resistive voltage dividers to reduce voltage. What about a circuit that boosts voltage to a value greater than the supply $V_S = 5V$? We can do this with capacitors!



(a) In the circuit above switches ϕ_1 are initially closed and switch ϕ_2 is initially open. Calculate the value of the output voltage, V_{out} with respect to ground, and the amount of charge stored on capacitor, C, at that state (phase 1).



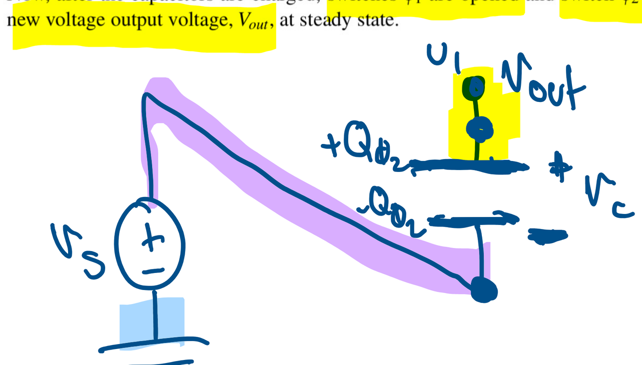
$V_C = V_S$

$Q_{\phi_1} = CV = C \cdot V_s$

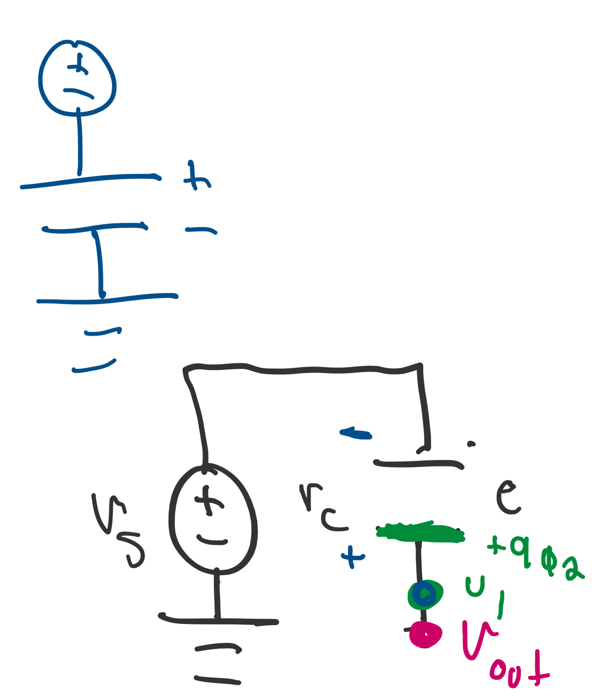
$V_{out} = V_S$

$Q_{\phi_1} = C V_{out}$

(b) Now, after the capacitors are charged, switches ϕ_1 are opened and switch ϕ_2 is closed. Calculate the new voltage output voltage, V_{out}, at steady state.



$V_C = u_1 - V_S = V_{out} - V_S$



@ u_1: $C \cdot V_C = C \cdot (V_{out} - V_S)$

$C \cdot (V_{out} - V_S) = C \cdot V_S$

$+Q_{\phi_2}$ $\quad +Q_{\phi_1}$

$C \cdot V_{out} - CV_S = CV_S$

$C \cdot V_{out} = 2 C V_S$

$$V_{out} = 2 \cdot V_S$$