SP.764, Practical Electronics
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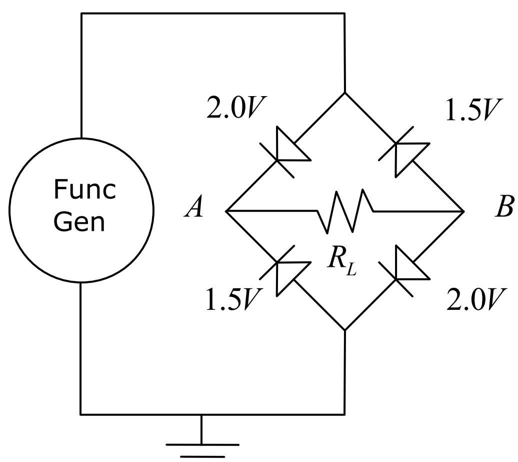
Lecture 3: Capacitors

Topics:

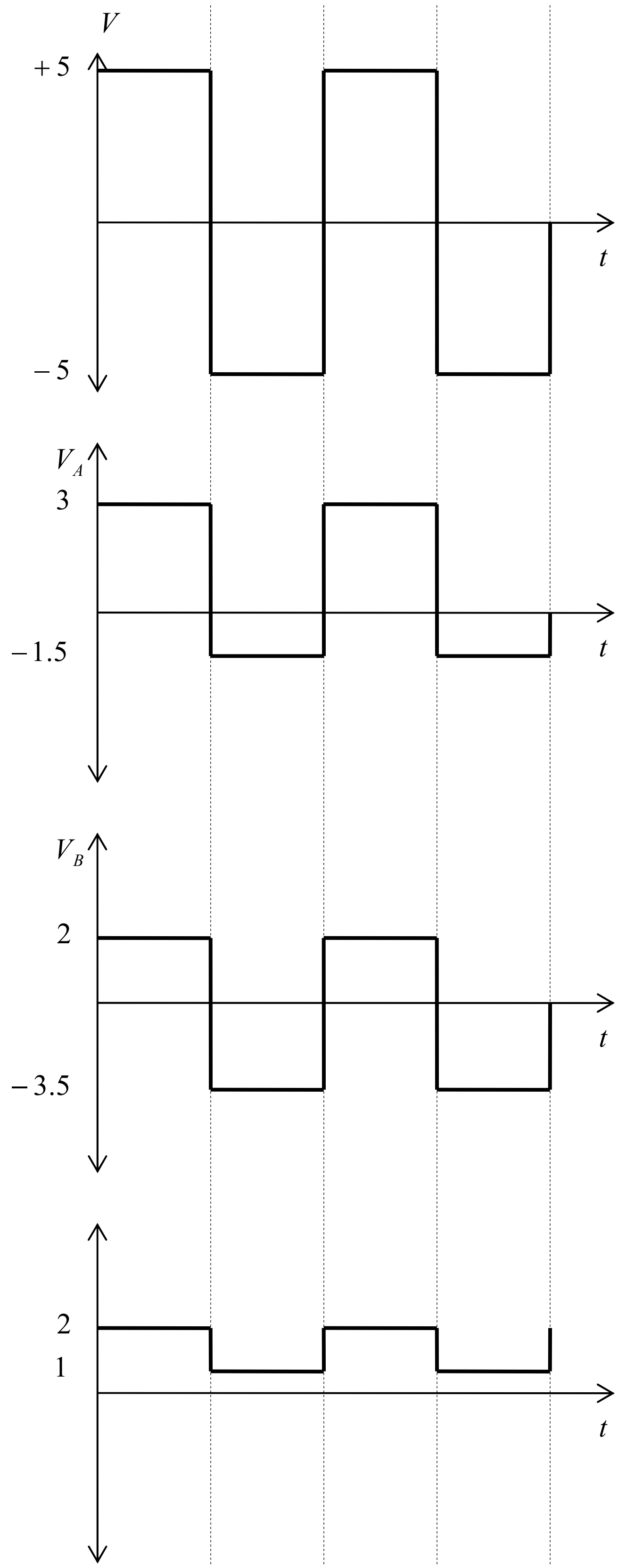
1) Review Homework
2) Capacitors
   - Time varying systems
   - Water analogy
   - What capacitors are
   - How they work
   - Constitutive systems
   - RC circuits

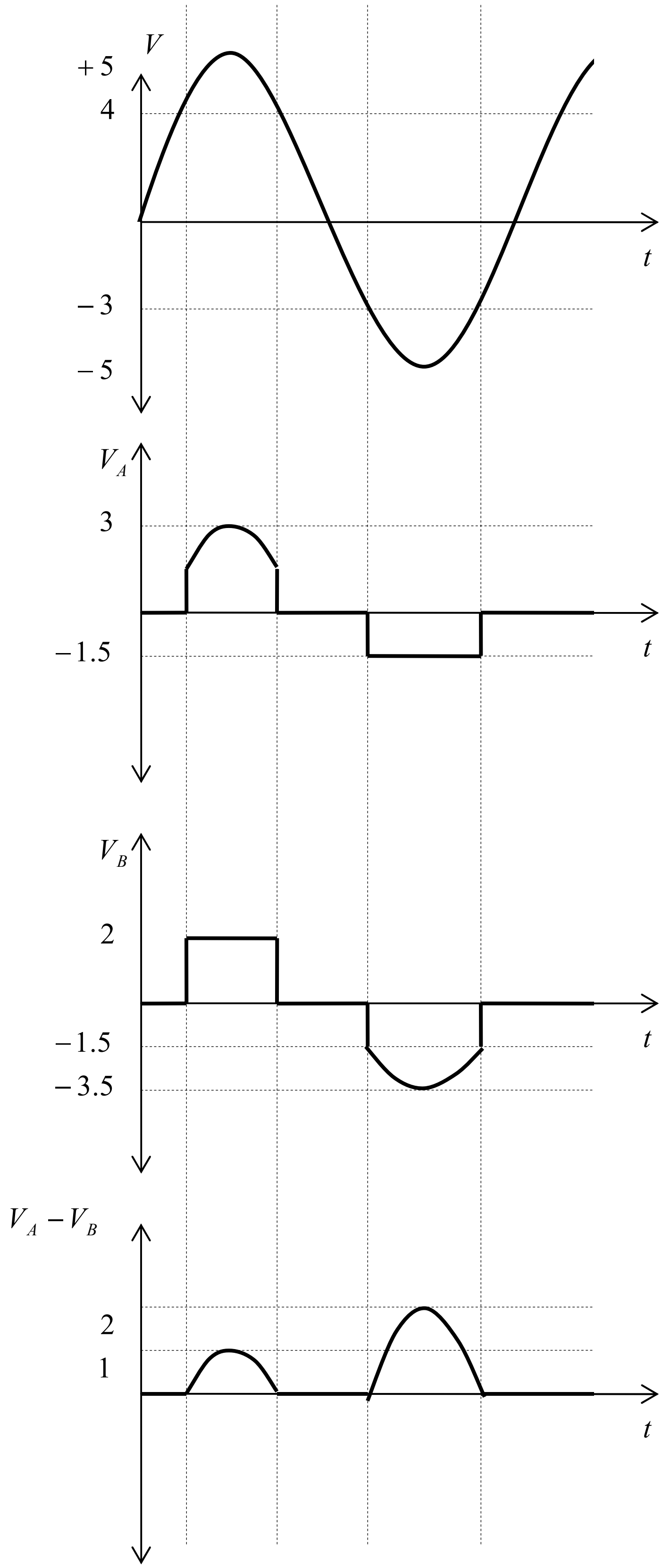
Homework Review:



For "positive" part of cycle:
V_A = 3V, V_B = 2V

For "negative" part of cycle:
V_A = -1.5V, V_B = -3.5V


V
+5
t
−5
V_A
3
t
−1.5
V_B
2
t
−3.5
2
1
t


V
+5
4
−3
−5
t
V_A
3
−1.5
t
V_B
2
−1.5
−3.5
t
$V_A - V_B$
2
1
t

Capacitors:

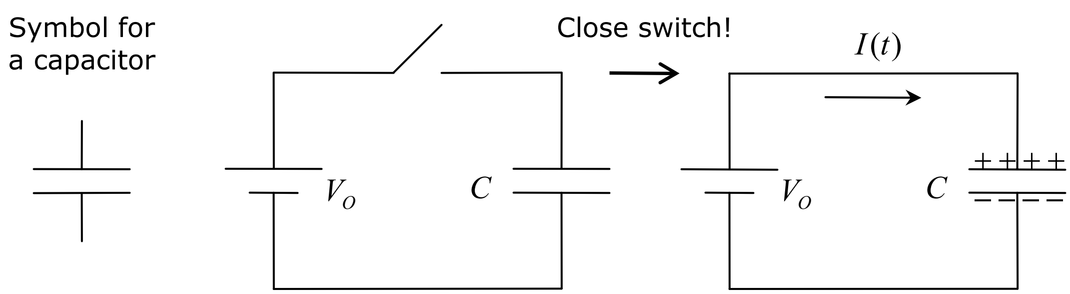
<u>Water Analogy</u>

Voltage ⇔ Pressure

Current ⇔ Volumetric Flow Rate

A capacitor is a bucket for charge!

In the fluid system, voltage is equivalent to pressure. Current maps to the volumetric flow rate of water. Looking inside a pipe, one would say water is flowing at a rate of gallons per second. The water analogy is used because the easiest way to think about this is that the capacitor is a bucket for charge. That is, the capacitor can store charge and can release charge as needed.

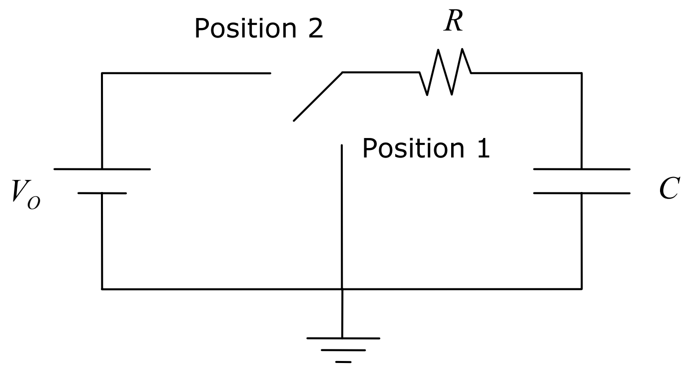


The symbol for a capacitor is two metal plates (two pieces of metals separated by air. If a battery is added with voltage V_0 and a switch, then current will flow if the switch is closed.

How is I related to q?

- For a resistor, I = V/R. Since I is the flow rate of charge, then I = dq/dt.
- For a capacitor, the amount of charge "q" on a plate obeys: q = CV. Therefore when the switch is closed, current starts flowing until q = $CV_{0.}$

Resistor	Capacitor
$I = \frac{V}{R} = \frac{dq}{dt}$	$I = \frac{dq}{dt} = C\frac{dV}{dt}$



The switch starts at position 1, and at time t = 0, the switch goes instantaneously to position 2.

Question: What is V_{CAP} as a function of time?

For $t \le 0$, V_{CAP}?

For $t \le 0$, $q = 0$, so $V_{CAP} = 0$.

At $t = 0$, flip switch:

$q(t) = CV_{CAP}(t)$

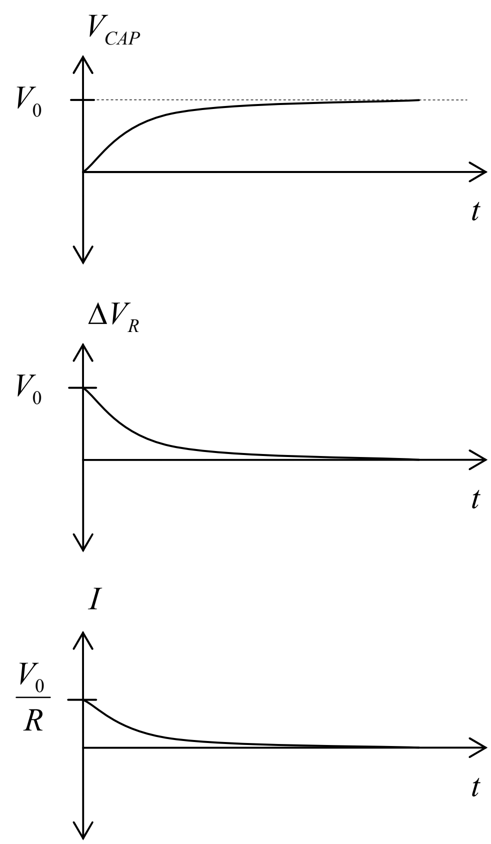
ΔV across resistor is $\Delta V(t = 0) = V_0$

$$I(t=0) = \frac{V_0}{R}$$

$$V_{CAP}(t) = V_0\left(1 - e^{-\frac{t}{RC}}\right)$$

$$I(t) = \frac{V_0}{R}e^{-\frac{t}{RC}}$$

RC = time constant



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