Administrivia

- WTh 5 - 8 lab cancelled
- Reading newsgroups outside campus using Windows: Check webpage!
- Confusion in last lecture: concept of ground. Answered in newsgroup.
- Supernode example in lecture 3 - look at my complete notes tomorrow.
- I will put up all complete notes by tomorrow - sorry for the delay.
- Practice problems will be up by this weekend.
- Lab 1, 2 and 3 solutions will also be enabled by this weekend.

Last Time...

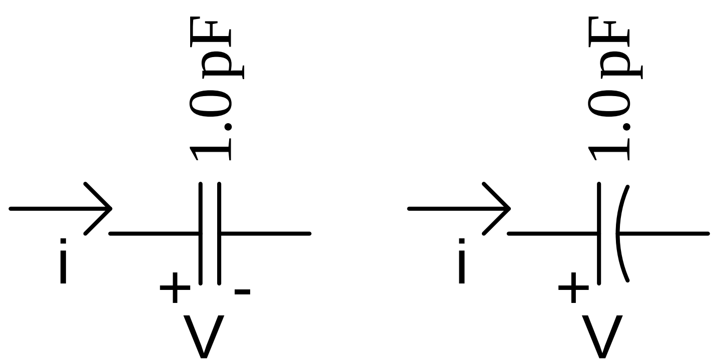
- Circuit analysis tools: Voltage and current divider, nodal analysis
- Instruments: Voltmeters and Ammeters.
- **Do you have questions on any of these concepts?**

This Time...

- Capacitors
  - Properties
  - Equivalent capacitance - Series and Parallel
- RC Circuits
  - Natural and step response: example
- A look at propogation delay

Capacitors

- What is a capacitor?
  - A passive element that stores electrical energy.
- Circuit symbol:



Capacitors: IV relationship

- Let q be measured in coloumbs, C in farads and V in volts. Then:
  - q = CV.
  - Assuming C is constant and differentiating with respect to t,

$$i = C\frac{dV}{dt}$$

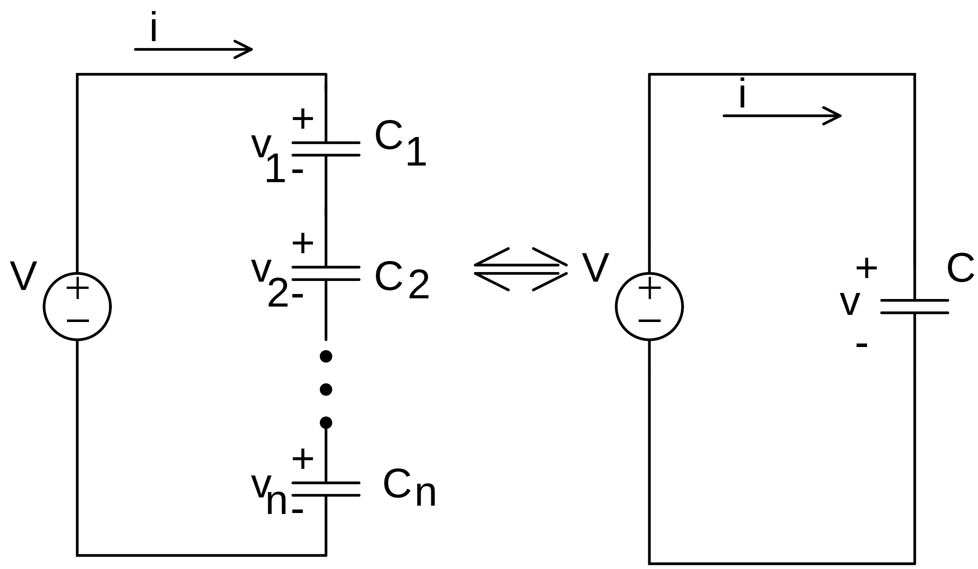
- Remember the passive sign convention!
- Expression for Power = VI = _____

Capacitors: Two important ideas

- Voltage cannot change instantaneously across the terminals of a capacitor.
- If voltage across the capacitor is constant, the capacitor current is zero.

Equivalent capacitances

- Let us go through the series example from your notes.



$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

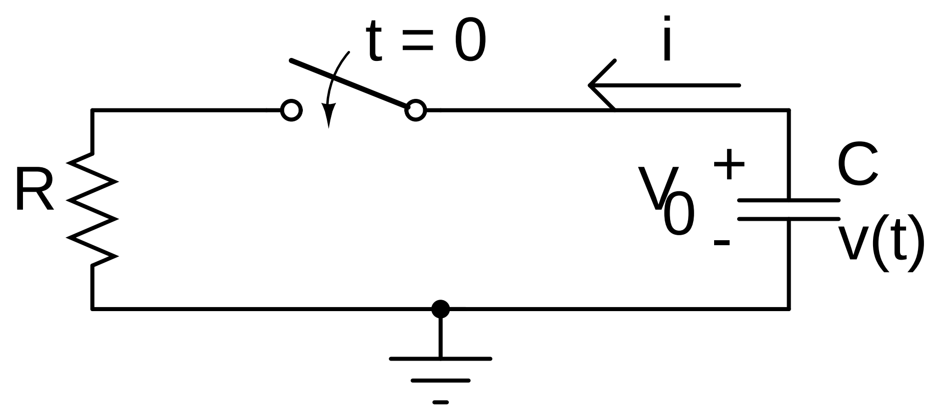
- Caps in parallel: exercise (hint: use KCL and capacitor IV relationship)

RC circuits: Introduction

- RC circuit:
- Analyze circuit in two phases:
  - Natural Response
  - Forced (or step) Response

RC circuits: Natural Response

- The circuit we will use is shown below:



RC circuits: Natural Response

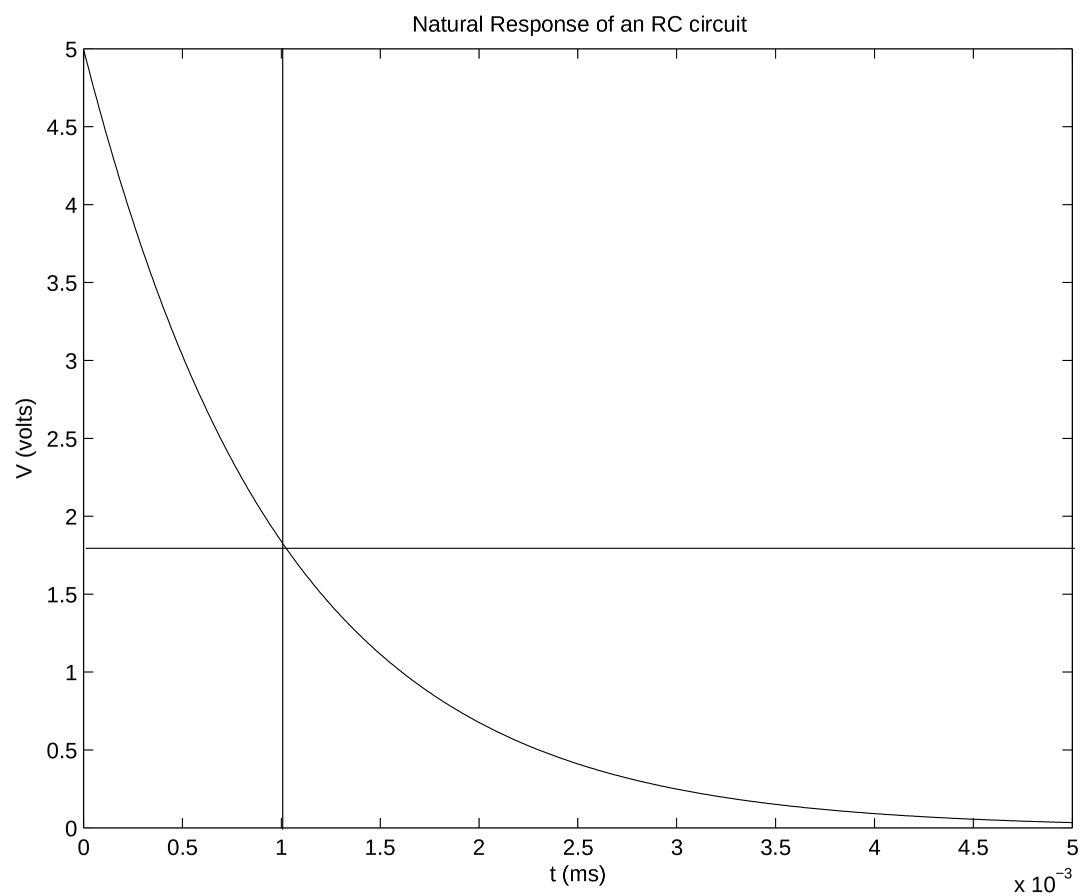
- The output voltage function is:

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

- In the equation above: we have a **time constant** of τ = RC.
  - Useful to think about multiples of time constants.
  - Important multiples: One time constant (e^{-1}) and 5 time constants (e^{-5})

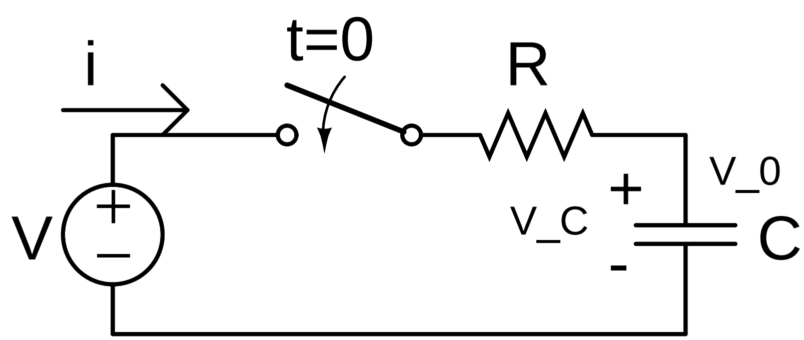
RC circuits: Concept of a time constant

- Understand time constant better by looking at a plot of v(t):



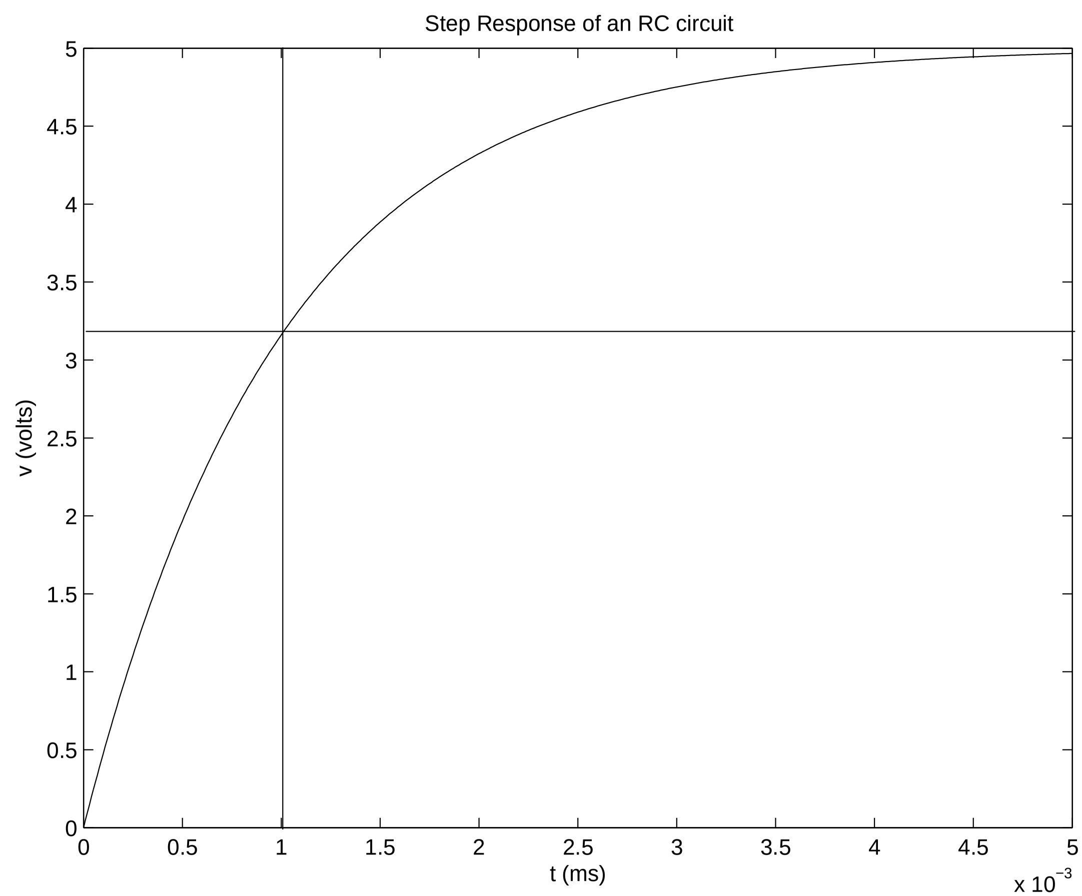
RC circuits: Forced Response

- The circuit we will use is shown below:



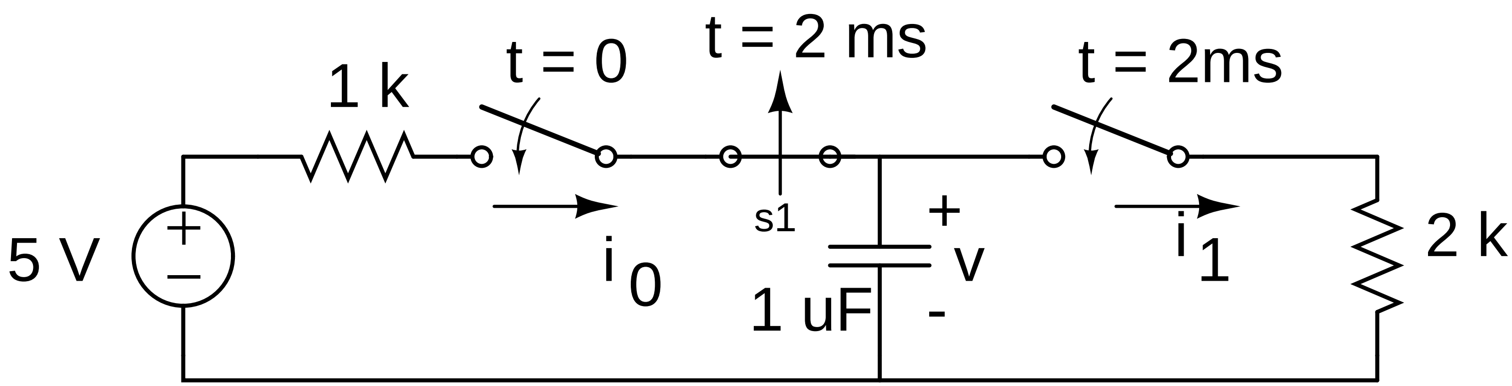
RC circuits: Forced Response Plot

- A plot of the forced response is shown below (V_0 = 0 V, V = 5 V, τ = 1 ms)



RC circuits: An example

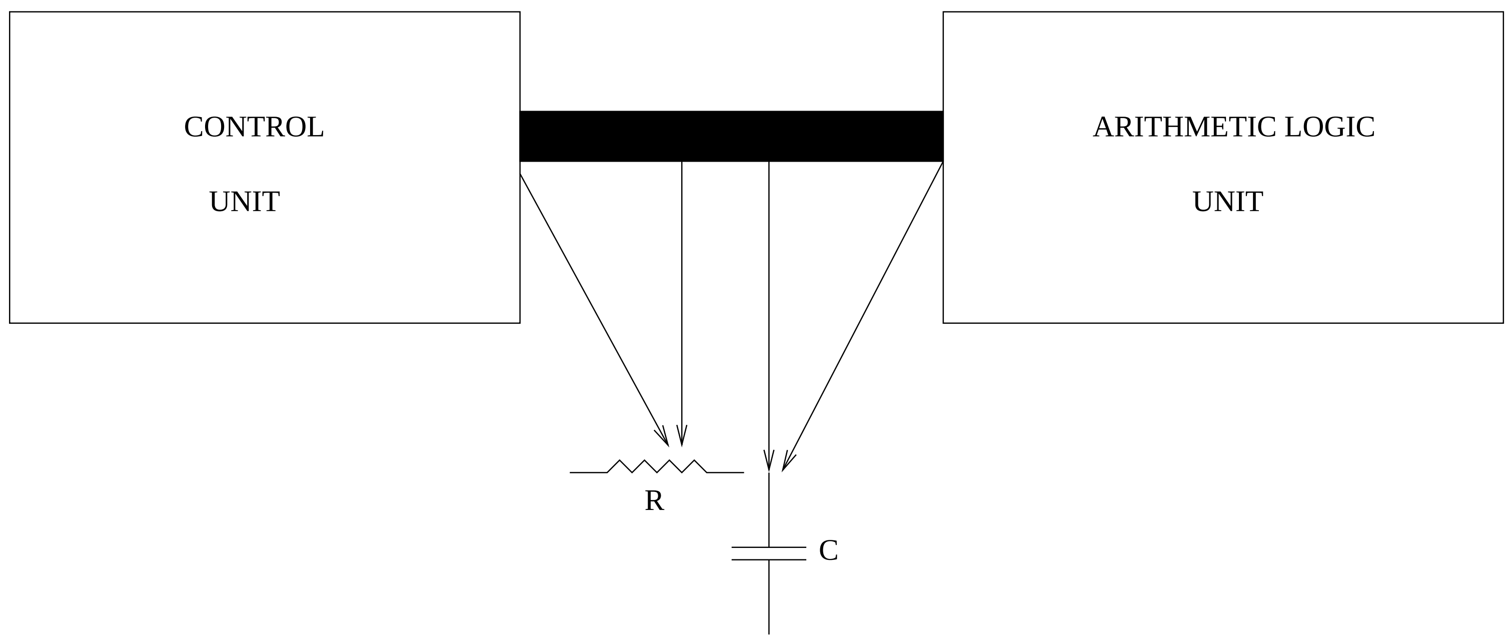
- In the circuit below



- Assume capacitor is initially uncharged. Find: $i_0(0^-)$, $i_0(0^+)$, $v_{s1}(2^-)$ (voltage across switch s1), $v_{s1}(2^+)$, $i_1(2^-)$, $i_1(2^+)$ and an expression for v.

Propogation delay model

- Consider the high-level view of your microprocessor:



Summary

- We studied a very important practical circuit element: the capacitor
  - IV relationship
  - Two important Properties
  - Equivalent capacitance: capacitors in series and parallel
  - Analyzing RC circuits
- You will see a propogation delay application in HW #2.
- Inductors: HW #2.

In Conclusion...

- Next time:
  - Thevenin and Norton theorems
  - Intro. to op-amps
- Reading for today: handout.
- Reading for Wednesday: 4.10 and 4.11 from reader
- In lab this week: RC circuits and make-up
- Please send me feedback (if any)!
- Questions?