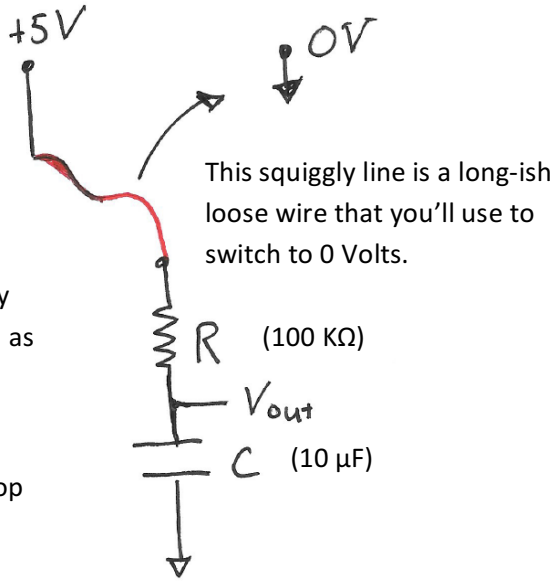
Problem set: Capacitors and RC circuits.

In this week's lab, we will start to use capacitors and learn about their wonders.

Part 1: How do capacitors respond to voltage?

Goal: Learn how a capacitor and resistor respond to V inputs.

1. Build the circuit shown



This squiggly line is a long-ish loose wire that you'll use to switch to 0 Volts.

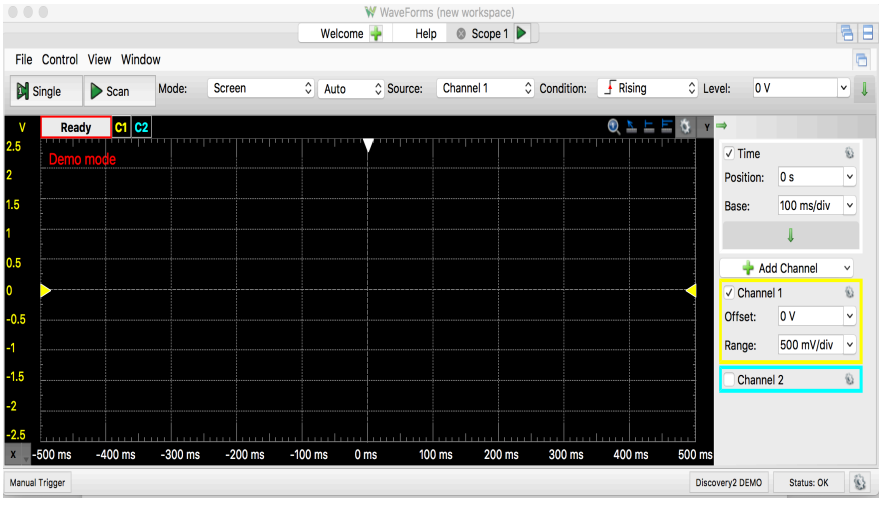
2. Connect the Discovery to your circuit.

Make sure the Discovery shares the same ground as your circuit.

Use Scope Channel 1 to measure the voltage drop *across* the capacitor.

3. Set Waveforms data collection conditions and ▸Scan

Your time scale should be set to around 1 second/division.



What should you use for the voltage range?

4. Ground the circuit and monitor the changes

By hand, quickly move the wire at +5V to ground. Watch the voltage <u>*across*</u> the capacitor change with time. We call this behavior "discharging" –(*dis-* charging, *what do you think is happening?)*

During the capacitor's discharge, note that the measured voltage across the capacitor is the same as the voltage across the resistor.

- Plot V(t). Compute the product of R and C in units of seconds.
- Compare the measurement to the analytical solution which would be $V(t) = 5V\ e^{-t/RC}$. You may need to add a constant offset to time in your experimental data such that the plot starts at t=0. Also, your starting voltage on discharge from the experiment will not be 5 volts exactly - so you can use the experimentally determined starting point in your plot of the predicted curve - $V(t) = V(0)\ e^{-t/RC}$. *What does RC tell you about this circuit?*
- Compute and plot I(t) from the measured data.
- Use the analytical expression C dV/dt to compute the current through the capacitor; plot it and compare to I(t) for the resistor. *How are these currents related? Drawing a circuit could help to answer this question.*

Part 2: How do RC circuits respond to AC input voltages?

<u>Goal</u>: Learn how an RC circuit responds to AC signals and how this behavior can be used on signals.

(Please return the 10 µF capacitors to their proper bins.)

1. Build the circuit shown

Use Wavegen 1 as the V_input

Use Scope <u>Channel 1</u> to monitor V_input;

Use Scope <u>Channel 2</u> to monitor the V dropped <u>*across*</u> the capacitor.

The Discovery and circuit should share a ground.

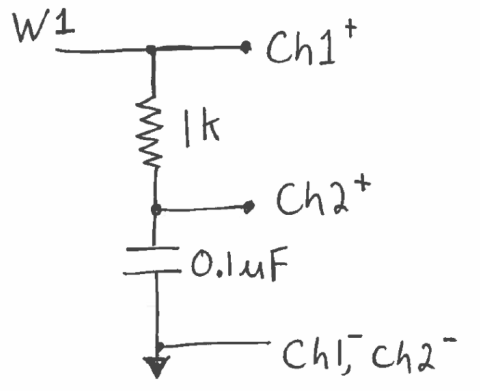
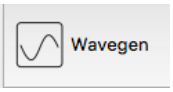


Figure 1: Simple RC circuit for part 2 of the lab.

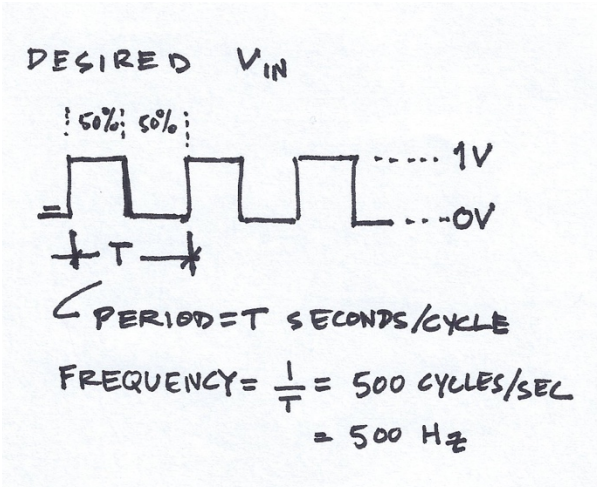
2. Connect the Discovery to your circuit.

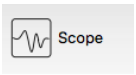
You should have nothing from the Analog Discovery connected to the 5 Volt power rail on your breadboard.

3. Set Waveforms Wavegen, Scope conditions and ▸Scan

Use 

to create the input signal and then ▸Run



Setup 

in MODE: Screen

Set the time scale to 500 µs per division Channels 1 and 2 should use the same volts/division with 0V offset. *What value should you use for the voltage scale?*

▸Scan.

If the signal is scrolling by on the screen, you can fix the data to the t=0 point by specifying Trigger conditions: *What data source? What condition of the data? What level of the condition*

In what ways is this response similar to or different from the response you got from Part I?

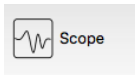
4. Test the frequency response of the RC circuit

While the Scope is running, go back to the WaveGen. Turn the frequency up to 1.5 kHz and see what happens.

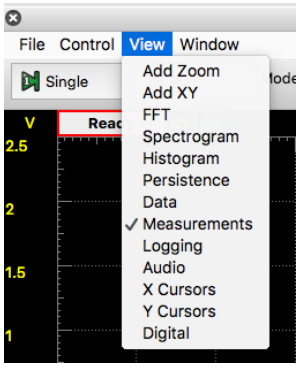
Now, try adjusting the frequency up and down to observe what happens to the output signal as frequency increases.

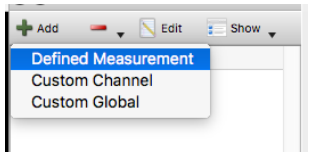
The behavior you observe should be the similar as in Figure 3.9 of the book.

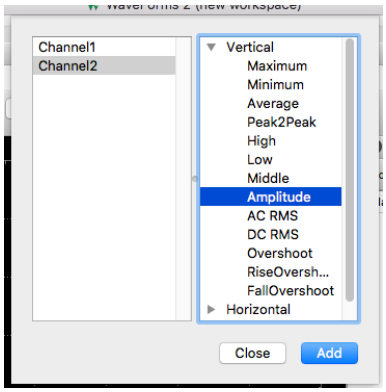
5. Generate a visual graph of how the RC circuit responds to inputs of differing frequency

In 

, add a measurement of Channel 2 Amplitude.

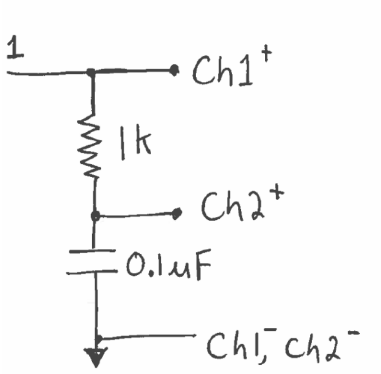






Now adjust the V_in frequency successively and record the voltage drop over the capacitor.

V_in frequencies	ΔV over capacitor
500 Hz	
1 kHz	
2 kHz	
5 kHz	
10 kHz	
50 kHz	
100 kHz	
200 kHz	



For your homework, you will plot this data on a log-log plot. To create a log scale plot in MATLAB you can type,

- loglog([500 1e3 2e3 5e3 1e4 2e4 5e4 1e5 2e5],[x x x x x x x x x])

where "x" are your recorded values of V amplitude.

Deliverables:

For this assignment, you turn in the plots you were requested to make. Create plots with clear axis labels with units. The plot should be well labeled. This is not a lab report, so just the plots.