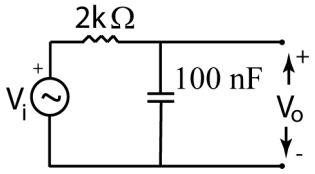
**Physics 242 – Electronics**

**Experiment 3 – RC Low-Pass Filter**

## Introduction

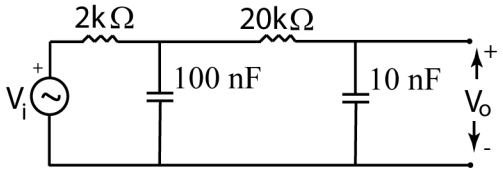
The complex impedances of the capacitor and inductor depend on frequency. Therefore, AC circuits containing capacitors and inductors can exhibit a frequency-dependence, serving as filters with a frequency-dependent response. Two of the simplest and most useful filter circuits are the RC low-pass and RC high-pass filters, which are in essence frequency-dependent voltage dividers. In this experiment, we will investigate the behavior of single-stage and two-stage RC low-pass filters.

## Procedure and Questions




1. Construct the circuit shown above, using a nominally 2 kΩ resistor and 100 nF capacitor. Measure your component values first, using the LCR meter to measure the capacitance. Set the amplitude of your function generator to 1.0 V peak-to-peak. Measure $V_i$ with the oscilloscope. Then measure the peak-to-peak amplitude $V_o$ carefully with the 'scope at a series of frequencies from 1 Hz to 1 MHz, or whatever is the maximum frequency provided by your signal generator. Since the frequency range spans several orders of magnitude, you'll plot your results on a log scale, so it's most efficient to use frequencies that vary logarithmically, like 1, 2, 5, 10, 20, 50, etc. Take a few extra measurements around the point where the amplitude of $V_o$ first begins to decrease. Also, calculate the cut-off frequency of the filter (the frequency at which the output voltage is reduced by a factor of $\sqrt{2}$; i.e. where $V_o = \frac{1}{\sqrt{2}} V_i$) and measure the output voltage at the cut-off frequency.

Plot the amplitude ratio in decibels vs. frequency *f*. Use a log scale for the frequency axis. Recall that the amplitude ratio in decibels is given by $20 \log_{10}\left(\frac{V_o}{V_i}\right)$. Fit a line to the straight-line part of the plot where the amplitude ratio is decreasing steadily. Is the slope near the predicted value of 20 dB decrease per decade of frequency?




2. Next, build a second low-pass filter stage to follow your existing filter circuit. Use a resistor of nominal value 20 kΩ and a capacitor of nominal value 10 nF (but measure their actual values

before connecting them into your circuit). For a 1.0 V peak-to-peak input voltage, measure the output voltage as a function of frequency as before (but you need not take extra point around the cut-off frequency this time). Make a plot as before, and measure the slope in the region where is exhibits a linear decrease. What slope value do you find? Is the measured value in accord with your expectations for a two-stage RC low-pass filter? Explain briefly.