# Lab 3: Passive Components

U.C. Davis Physics 116A
10/8/2003

## INTRODUCTION

In this lab you will build a Thévenin equivalent circuit and a low-pass filter and will characterize each.

## 1. THÉVENIN EQUIVALENT CIRCUIT

In this section, you will build a circuit and its Thévenin equivalent and see how equivalent these two circuits really are. Construct the circuit shown in figure 1, a voltage divider with load resistance, $R_L$. For your lab report, calculate and measure the voltage at point *V* for two values of $R_L$, 1kΩ and 10kΩ. Be sure to include uncertainties in your measurements and to discuss the agreement between the calculated and measured values.

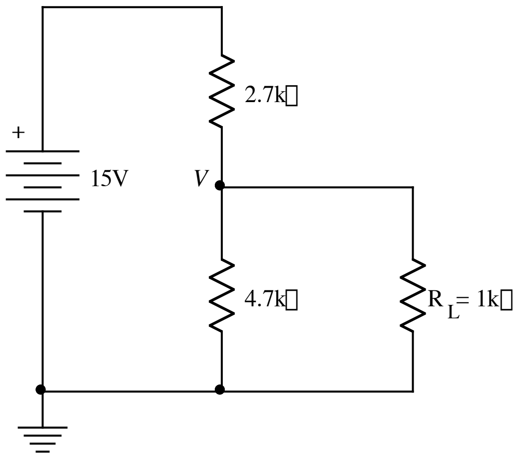

Figure 1: Circuit for demonstrating Thévenin equivalent.

Now calculate the *r* and *e* for the Thévenin equivalent of the above circuit. The Thévenin equivalent circuit is shown in figure 2. Construct this circuit using the variable voltage power supply for *e* and some combination of resistors for *r*. For your report, show your Thévenin calculation, measure your actual *e*, *r*, and voltage at *V*, and compare *V* with the circuit above and with theory.

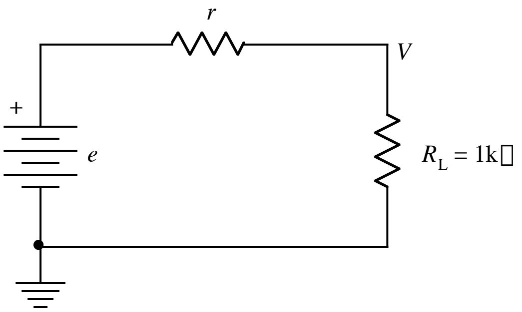

Figure 2: Thévenin equivalent for circuit of figure 1.

## 2. LOW PASS FILTER

In this section, you will measure the frequency response of a low pass filter circuit and see what the "low pass" name refers to. Construct the circuit shown in figure 3 using the function generator as the AC source. Use a 10V peak to peak sine wave as the $v_{in}$ source signal. Use both channels of the oscilloscope to monitor $V_{in}$ and $V_{out}$ simultaneously showing their phase relationship as follows. Connect Ch. 1 to $V_{in}$ and Ch. 2 to $V_{out}$. Set the oscilloscope to trigger on Ch. 1 only and adjust the trigger level until the trace starts at zero with positive slope. Ch. 1 will now display a sine wave. The phase difference of Ch. 2 will now be evident through the different starting value its trace and the overall displacement of the Ch. 2 waveform relative to Ch. 1.

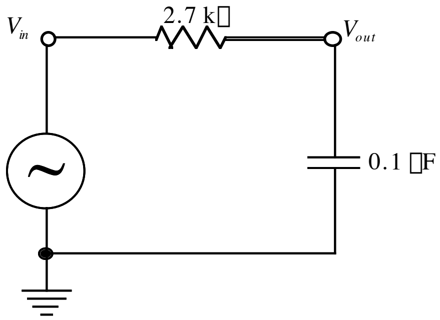

Figure 3: Low pass filter circuit.

The input and output signals can now be expressed as:

$$V_{in}(t) = v_{inm}\sin(\omega t),$$
$$V_{out}(t) = v_{outm}\sin(\omega t + \phi),$$

where $v_{inm}$ and $v_{outm}$ are the amplitudes of the input and output waveforms, respectively.

Calculate the break frequency (or corner frequency) $f_{\mathrm{b}} = \omega_{\mathrm{b}}/2\pi$ for this circuit. Use this frequency and select 10 other frequencies, 5 above $f_{\mathrm{b}}$ and 5 below $f_{\mathrm{b}}$. For each frequency, measure the voltage gain,

$$A_v = \frac{v_{outm}}{v_{inm}},$$

and the phase shift, $\phi$, of $V_{out}$ relative to $V_{in}$. Bear in mind that you will want to find the slope of the fall-off of the gain on the log-log plot at high frequencies.

For your lab report, include your $f_{\mathrm{b}}$ calculation, your gain and phase shift data, and 4 separate graphs of the data. First, make a linear-linear graph of gain *vs.* frequency and phase angle *vs.* frequency, indicating $f_{\mathrm{b}}$ on each. (That's 2 graphs.) Then, make a log-log plot of gain *vs.* frequency and a semi-log plot of phase angle (linear) *vs.* frequency (log), comparing the data to the theoretical Bode plots for gain and phase angle. (That's the other 2.)

## 3. HIGH PASS FILTER

Design an RC high-pass filter with $f_{\mathrm{b}} = 10\mathrm{kHz}$. Build it and take enough data to make Bode plots for gain and phase. For your report, include a description of how you designed the circuit and the two Bode plots (each of which includes data points and a theoretical plot).