Purpose

The purpose of this experiment is to investigate the concept of resonance. The sinusoidal response as well as the step response of a second-order circuit will be considered. In addition, a technique for measuring capacitance and inductance will be introduced.

Preliminary Measurements Before the resonance circuit can be considered, the component values of each of the circuit elements must be measured.

1. Function generator output resistance: The starting point of all of the measurements is to determine the output resistance of the function generator (recall the model for a practical voltage source). The easiest way to measure the output resistance of the function generator is to consider it as a Thevenin equivalent circuit. Any two voltage or current measurements may be used to determine the Thevenin resistance. However, the following two measurements are often used. First, the output voltage is measured when a known load resistor is connected. Next, the output voltage is measured when a known load resistor is connected. (Hint: use a resistance around 50Ω.) Simple voltage division of the open circuit voltage (Thevenin voltage) between the known load resistor and the generator output resistance yields the desired Thevenin resistance.

2. Capacitance value: (Use the 0.01µf capacitor in your lab kit for this capacitor.) Now that the resistance of the generator is known, its value may be used to determine the actual capacitance of the capacitor. When the capacitor is connected across the waveform generator output, a first order system (see Figure 1) is formed between the generator resistance and the capacitor.

3. Inductance value: A decade inductance box set for a 10 mH inductance is connected to the waveform generator creating a first order circuit comparable to the one in Figure 1 (replacing the capacitor by the inductor). Having calculated the inductor voltage, repeat the method used to determine the capacitance for finding the value of the inductor.

4. Resistances: (Use 1/4W-carbon resistors from the 117-lab kit.) Use the DMM to measure the values of the 1KΩ and the 51Ω resistors.
3. **Experimental**: The sinusoidal steady state response for only three frequencies will be measured. The oscilloscope will be used to observe the input and output waveforms. Slowly adjust the input frequency until the center frequency, \( f_n \), is found. This is the frequency where the output is a maximum. The gain and phase shift (from \( V_{in} \) to \( V_{out,1} \)) at this frequency should be measured. The lower half-power point is found by decreasing the frequency until the output amplitude is down to 70.7% of the center frequency amplitude. The upper half-power point is found by increasing the frequency until the output amplitude is 70.7% of the center frequency amplitude. The gain and phase shift at the lower and upper half power points should be measured.

4. **Comparison**: A table should be constructed that shows all of the gains, phase shifts, frequencies and bandwidths for the theoretical, PSPICE and experimental values found in sections 1 through 3 above.

## Step Response

The same circuit is used for this part as was used for the sinusoidal steady state response. For the PSPICE simulation, a unit step input is used. Since it is relatively difficult to observe a single event on the oscilloscope, a square wave input will be used for the experimental part. No theoretical analysis is required for this section.

1. **PSPICE**: For the PSPICE analysis, a DC source of 1 volt is used for the input signal. (Use the 51Ω resistor to represent the internal generator resistance.) A TRAN analysis is used. The final time should be long enough for the output to practically reach steady state. The print size and step ceiling should allow about 500 steps from beginning to end. The output graph should show the input and output signals superimposed on one page.

2. **Experimental**: The experimental part of this section uses a square wave input. The period of the square wave should be twice the value used for the PSPICE final time. (Think about that and explain why in your report.) Use the GPIB program PLOT to plot the input and output waveforms on the same page.
Discussion Topics

1. Compare the measured values of the three components with the values stated on the devices.

2. Compare the theoretical, PSPICE and experimental values of the characteristics (bandwidth, resonant frequency, center frequency, and half power points) considered in the sinusoidal steady state part of the experiment.

3. Compare the gain and phase shifts at the half-power points.

4. Discuss the step responses obtained in the last section of the experiment. Were the initial and final values as expected? (Think about the initial and final voltages of inductors and capacitors.)

Pre-Lab (10 points)

Prior to the first laboratory period calculate the voltage across a capacitor C (do not use a specific value), and the voltage across an inductor L for the two first-order circuits (Figure 1) used in the Preliminary Measurements sections 2 and 3.

Pre-Lab (10 points)

Prior to the second laboratory period do the required PSPICE and theoretical calculations for the sinusoidal steady state and the step response sections.