Lab2, ECE 580

Objective
To become familiar with common response-plotting techniques through the analysis

Introduction
Bode plots is a very common way of graphically describing the performance of systems. The systems dealt with in this experiment are simple RC and RLC networks. However, the techniques are not restricted to basic networks and can be applied to quite complex systems. Their use however implies steady state sinusoidal excitation of the system under test.

In this experiment, you will measure the magnitudes and phases of transfer functions. You will measure how the magnitude and phase depend on frequency, and will plot the results on log-log and semi-log axes to produce a Bode plot. Your measurements will be performed on RLC circuits, as well as on several other simple filter circuits.

The Bode plot of transfer functions
A Bode plot is a plot of the magnitude and phase of a transfer function or other complex-valued quantity, versus frequency. Magnitude in decibels, and phase in degrees, are plotted vs. frequency, using log-log and semi-logarithmic axes. The magnitude plot is effectively a log-log plot, since the magnitude is expressed in decibels and the frequency axis is logarithmic. The use of a log-log plot is necessary because the range of frequencies and magnitudes typically includes many orders of magnitude.

Measurement of transfer functions
A signal generator and oscilloscope can be used to obtain manual measurements of magnitude and phase. The signal generator produces the sinusoid $v_{in}(t)$. The oscilloscope is connected to measure $v_{in}(t)$ and $v_{out}(t)$. The peak-to-peak magnitudes of $v_{in}(t)$ and $v_{out}(t)$ are measured. The ratio of these magnitudes is equal to the transfer function magnitude || $H(jw)$ ||:

$$\left\| H(j\omega) \right\| = \frac{\left\| \hat{V}_{out} \right\|}{\left\| \hat{V}_{in} \right\|}$$

It is more difficult to measure phase than magnitude, and some care and diligence is required to obtain accurate results. To measure the phase using an oscilloscope, the oscilloscope is triggered by $v_{in}(t)$, and the time per division is adjusted so that one period of $v_{in}(t)$ nearly fills the entire width of the screen (from the left edge of the graticule to the right edge). The trigger and horizontal postion controls are adjusted so that a positive-going zero crossing of $v_{in}(t)$ occurs at the center of the screen. The positive-going zero crossing of $v_{out}(t)$ is then found, and the horizontal distance between the positive-going zero crossings of v_{out} and v_{in} is measured. The phase shift between v_{out} and v_{in} is then given by

$$\angle H(j\omega) = \angle \hat{V}_{out} - \angle \hat{V}_{in}$$
$$= (360°) \frac{(\text{time between zero crossings})}{(\text{waveform period})}$$

The phase is positive when the positive-going zero crossing of $v_{out}(t)$ occurs before the positive-going zero crossing of $v_{in}(t)$. The phase can also be measured using the period and zero crossing waveform measurement functions of the oscilloscope.

Procedure

Determine each network's voltage transfer function (use either the complex frequency or the jω operator when deriving the functions)

Derive and plot the theoretical Bode diagrams and compare them with the experimentally determined plots. Show the asymptotic (straight line) approximate response in each case.

1. Measure Bode plot of R-C low-pass filter.

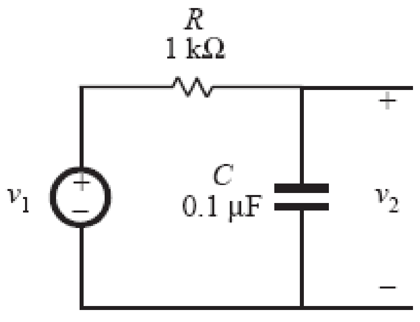


Figure 1

Connect the *R-C* network illustrated in Fig. 1. Apply a sinusoid to the circuit using the function generator, and set the frequency to the corner frequency of the *R-C* circuit. Measure the input and output voltage waveforms using the two channels of the oscilloscope.

2. Measure Bode plot of R-C band-pass filter.

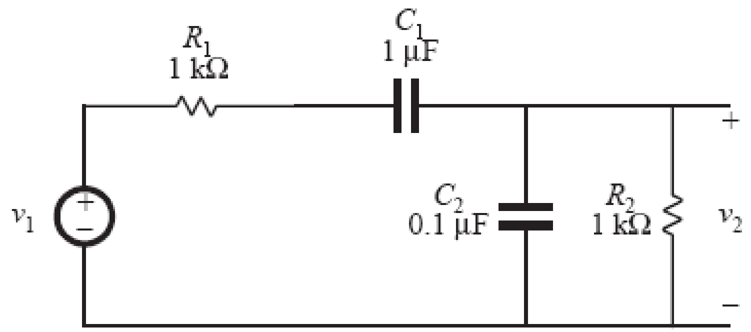


Figure 2

Construct the band-pass filter circuit illustrated in Fig. 2. Measure the magnitude and phase of the transfer function of this filter.

3. Measure Bode plot of RLC circuit transfer function.

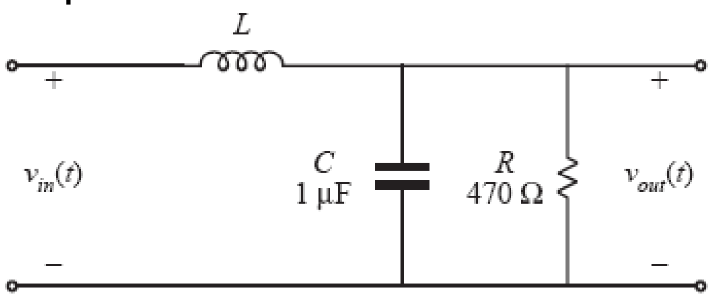


Figure 3

Measure the transfer function

$$H(j\omega) = \frac{\hat{V}_{out}}{\hat{V}_{in}}$$

Take measurements of magnitude and phase over the frequency range 100 Hz to 10 kHz. Take enough points to obtain reasonably smooth curves.

Change L to two different values, measure magnitude and phase over the frequency range 100 Hz to 10 kHz. Draw the bode Diagrams. Discuss the differences among different value of inductor.

Note: Be sure that you select more frequencies around breakpoint to make the plot more clearly.

Discussion

Discuss the form of the graphs and their relationship to the transfer functions.

Lab2 report , ECE 580

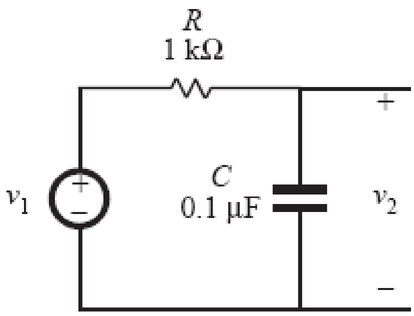
(Bode Plot)

Your Name:__________________________________

Partners: __________________________________

Date: __________________________________

1. R-C low-pass filter



Value of the circuit:

R:	
C:	

1) Transfer function of the circuit

2) Magnitude and phase

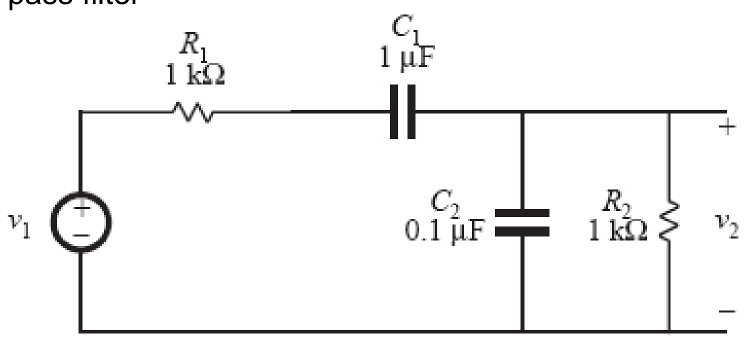
Frequency f	$\|V_{in}\|$	$\|V_{out}\|$	$M = \|V_{out}/V_{in}\|$	$20\log_{10}M$	$\text{Log}_{10}f$	Δt	ϕ

3) Theoretical Bode diagrams (Please label all axes(including units))
Magnitude vs frequency

Phase vs frequency

4) Experimentally determined bode plot
   a) Magnitude vs frequency (log-log plot)
   b) Phase vs frequency (semilog-log plot)
5) Explain the difference between theoretical and experimental plots

2. R-C band-pass filter



Value of the circuit:

R1:	
R2:	
C1:	
C2:	

1) Transfer function of the circuit

2) Magnitude and phase

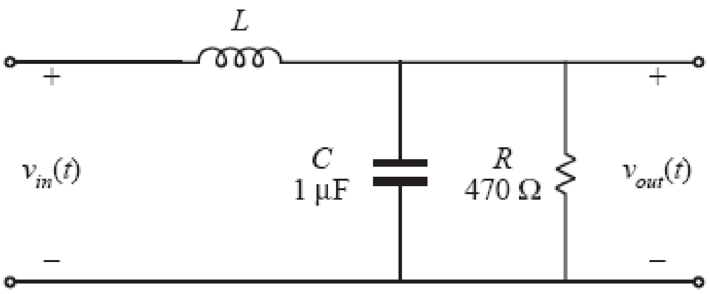
Frequency f	$\lvert V_{in} \rvert$	$\lvert V_{out} \rvert$	M = $\lvert V_{out}/V_{in} \rvert$	$20\log_{10}M$	$\text{Log}_{10}f$	Δt	ϕ

3) Theoretical Bode diagrams (Please label all axes(including units))
Magnitude vs frequency

Phase vs frequency

4) Experimentally determined bode plot
   a) Magnitude vs frequency (log-log plot)
   b) Phase vs frequency (semilog-log plot)
5) Explain the difference between theoretical and experimental plots

3. RLC circuit



Value of the circuit:

R:	
C:	
L:	

1) Transfer function of the circuit

2) Magnitude and phase

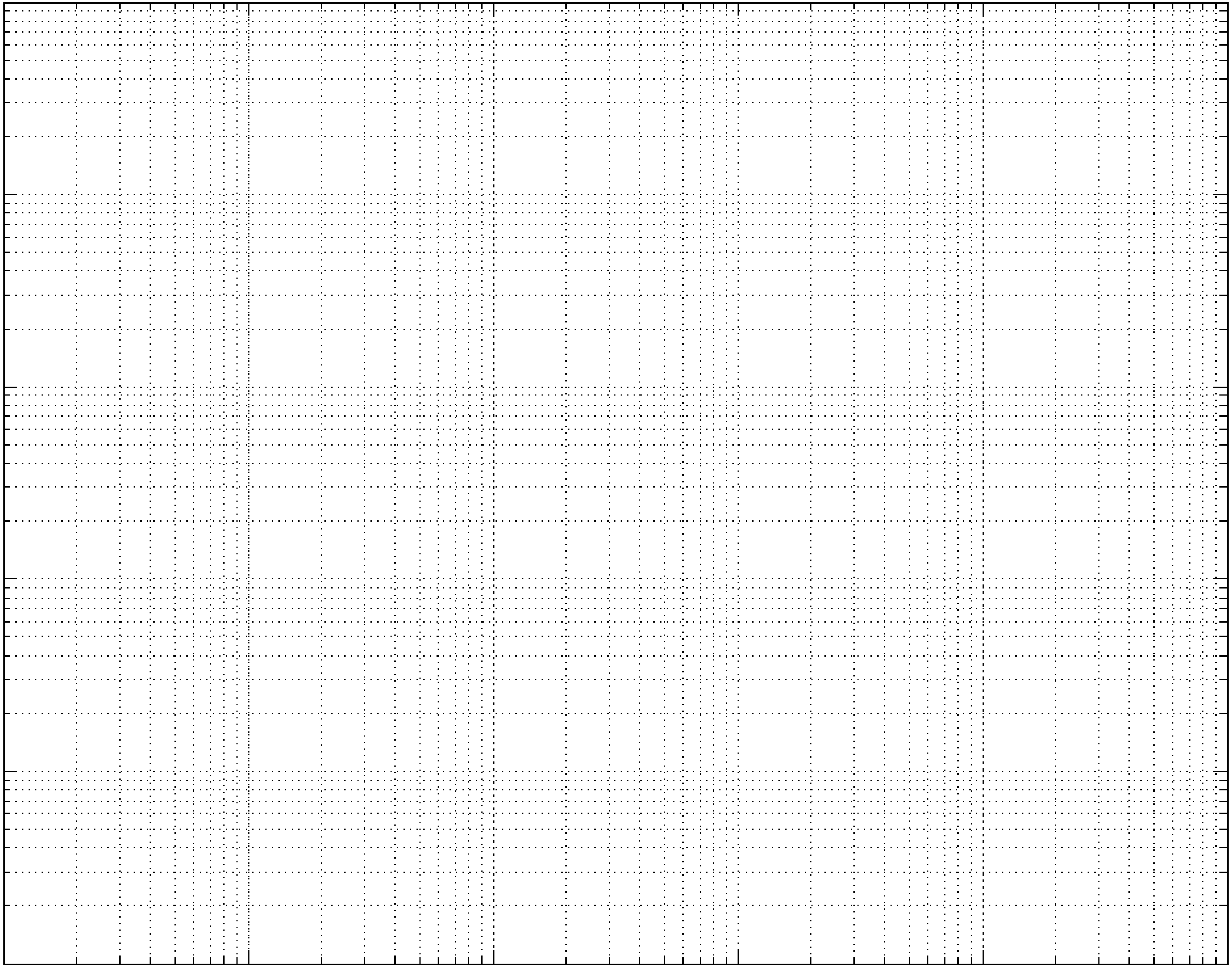
Frequency f	$\lvert V_{in} \rvert$	$\lvert V_{out} \rvert$	$M = \lvert V_{out}/V_{in} \rvert$	$20\log_{10}M$	$\mathrm{Log}_{10}f$	Δt	ϕ

3) Theoretical Bode diagrams (Please label all axes(including units))
Magnitude vs frequency

Phase vs frequency

4) Experimentally determined bode plot
   a) Magnitude vs frequency (log-log plot)
   b) Phase vs frequency (semilog-log plot)
5) Explain the difference between theoretical and experimental plots

log-log



semi-log