ECE-311 (ECE, NDSU)
Lab 12 – Experiment
RLC band-pass filters

1. Objective

- To measure the gain and phase angle of a band-pass filter.
- Verify that an RLC band-pass filter passes (or selects) a small frequency range.

2. Background

A filter is a circuit whose gain varies with frequency. By varying the components' values and the circuit topology, we can synthesize/design circuits which can "pass" low frequencies or high frequencies. If there is a signal, which is band-limited over a small frequency range, however, we may want a filter circuit that only "passes" frequencies in a small band. This is a band-pass filter.

3. Example circuit and gain analysis

An example of a band-pass filter is shown in Fig.1, where R = 1k, L = 1mH, C = 1uF.

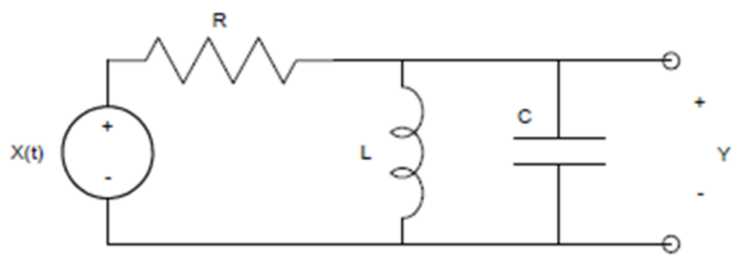

Figure 1: Band-pass filter example

Using voltage division, one can derive the expression that describes the gain of this circuit:

$$Y = \left(\frac{(j\omega L)}{R(1-\omega^2 LC)+(j\omega L)} \right) X$$

Note that the gain is zero at DC and high frequencies, and is a maximum at $\omega^2 LC = 1$. This is the band-pass filter with a pass band centered at $\omega = \omega_0 = 1/\sqrt{LC}$.

If we plot the magnitude Bode diagram in Matlab, then we get the graph shown in Fig.2:

```
L = 1e-3;
C = 1e-6;
R = 1000;
w = logspace(4,5,100);
Z1 = j*w*L ./ (1 - L*C*w.*w);
G = Z1 ./ (R + Z1);
plot(w,abs(G));
```

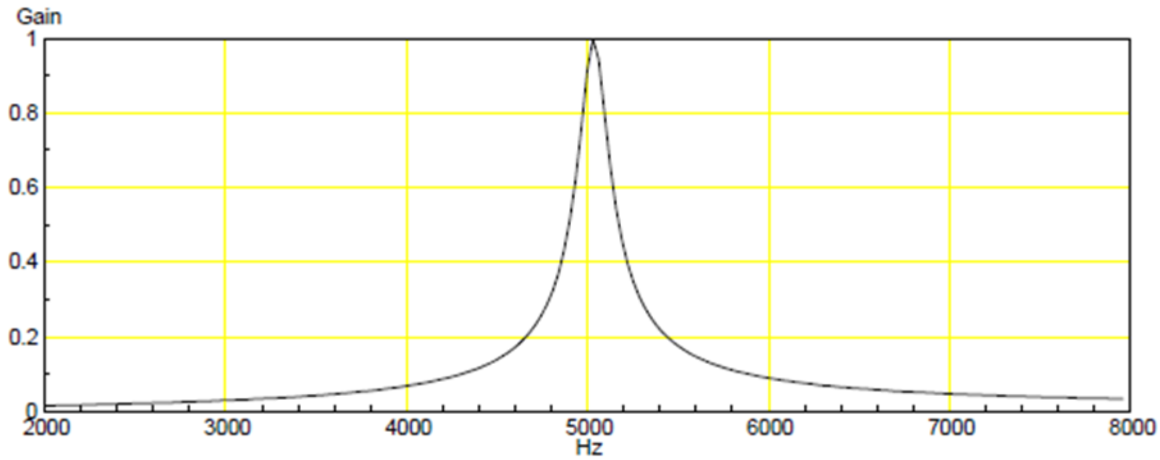

Figure 2: Magnitude Bode plot

4. Procedure

(1) Build the above circuit.

(2) Measure the gain vs. frequency from 2000 to 8000 Hz. Collect several data points near resonance to determine the shape of the pass band. Measure also the phase angle (or phase difference) between output and input signals.

(3) Plot your measured gain vs. frequency as well as the measured phase angle vs. frequency.

5. Lab report

(1) Compare your measured gain vs. frequency and phase vs. frequency plots with the plots obtained via theoretical analysis. Explain any differences.

(2) Is the resonance (gain = 1) frequency exactly 5032Hz as theory would predict?

(3) Suppose x(t) contained several sine waves:

$$x(t) = 10 \sin(10000t) + 3.3\sin(30000t) + 2 \sin(50000t)$$

What would y(t) be?