Laboratory 3

Electronics Engineering 3210

System Response to a Periodic Signal

Purpose:

This lab allows students to investigate the response of a periodic signal on a system, first by calculating the response using the Fourier series, then by implementing the circuit in hardware. The student also gains experience working with complex numbers in MATLAB.

Parts:

1 - 1kΩ resistor.
1 - 0.033μF capacitor.
1 - 1mH inductor

Preliminary:

Part 1. Find expressions for the exponential Fourier coefficients, D_n, of a square wave that has an amplitude of 4 Volts (8 Volts peak-to-peak) and no DC component (See Figure 1).

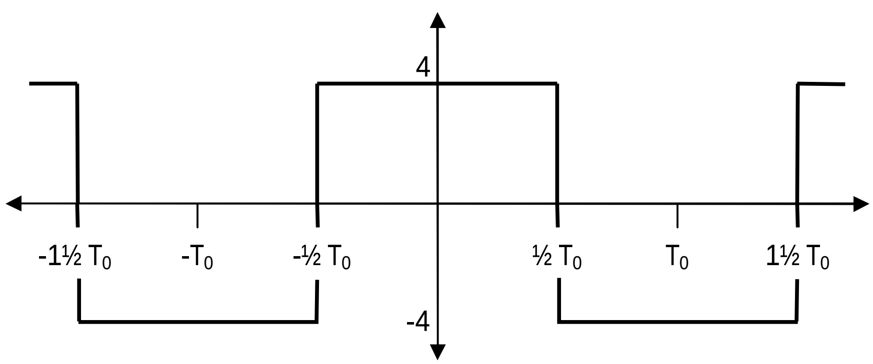

Figure 1 – Square Wave

Assume a frequency of 20kHz. Write a MATLAB script to reconstruct and plot the square wave using *m* harmonics as you did in Lab 2, except this time use the exponential Fourier series,

$$f(t) \cong \sum_{n=-m}^{m} D_n e^{jn\omega_0 t}$$

where $\omega_0 = 2\pi/T_0 = 4\text{x}10^4\pi$ (for 20kHz). (Note: In MATLAB, you can make a number imaginary by adding an i or j to the end of it, for example 2+3i. Thereafter, all operators, including the function exp( ), use complex arithmetic.)

A value of *m* = 35 gives good results, which means that you will need about 8x35 = 560 time steps per period.

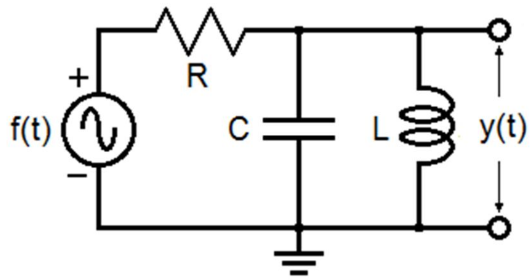

Figure 2. Series/Parallel Resonant Circuit

Part 2. Copy the circuit in Figure 2 into your lab book, then show that the system it represents is described by the differential equation:

$$\left(D^2 + \frac{1}{RC}D + \frac{1}{LC}\right)y(t) = \left(\frac{1}{RC}D\right)f(t)$$

Make a copy of your script from Part 1 and modify it to plot the *response* of this system to the square wave (See Section 3.7 of the text). Essentially this amounts to multiplying each term in the summation by $H(jn\omega_0)$, where

$$H(s) = \frac{P(s)}{Q(s)} = \frac{\frac{1}{RC}s}{s^2 + \frac{1}{RC}s + \frac{1}{LC}}$$

Use R = 1kΩ, C = 0.033µF and L = 1mH.

Procedure:

Write a title and short description of this lab on a new page of your lab book. Make an entry in the table of contents for this lab.

Run your first script and plot the reconstructed square wave (debugging if necessary). Affix a copy to your lab book along with your MATLAB script.

Run your second script and plot the system response (debugging if necessary). Affix a copy to your lab book along with your MATLAB script.

Connect the 1kΩ resistor, the 0.033µF capacitor and the 1mH inductor as shown in Figure 2. Connect the input to the function generator and attach a scope probe to the output. Configure the function generator to produce a 20kHz square wave with a 4V amplitude. Compare the scope output to your predicted response. It is unlikely they are exactly the same due to part tolerance. The easiest (but not the most accurate) way to compensate is to adjust the frequency until the images are similar.

Record your observations and write a conclusion in your lab book that summarizes what you have observed or discovered.