Laboratory 5

Electronics Engineering 3210

System Response to Non-periodic Signals

Purpose:

This lab allows students to investigate the response of a system to various inputs, first by calculating the response in the time domain, then by deriving the transfer function of the system, multiplying it by the signal in the frequency domain and taking the inverse Fourier transform. Students will then verify these results by experiment.

Parts:

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

Preliminary:

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.

Consider the system we used in Labs 3 and 4, shown below for convenience:

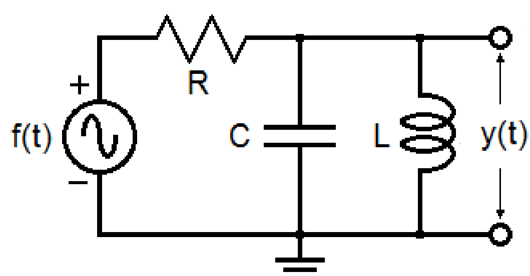

Figure 1. Series/Parallel Resonant Circuit

Let R = 1kΩ, C = 0.033μF and L = 1mH. Recall that this system is described by the differential equation:

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

Write a MATLAB script that computes the unit impulse response, $h(t)$, for this system over the interval [0,300μs]. Use a time step of $1.0\text{x}10^{-7}$. Refer to your notes from Lab 4 if necessary.

Add code to the script to create a signal (vector) for $f(t) = \Delta\left(\frac{t-10^{-4}}{2\times10^{-4}}\right)$ as shown in Figure 2. Plot this signal (against t) and affix a copy of the graph to your lab book.

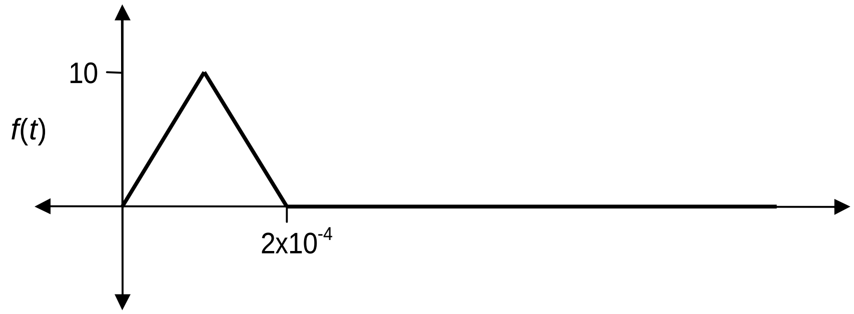

Figure 2. Input (Stimulus) Signal #1

Convolve $f(t)$ and $h(t)$ to obtain the output of the system, $y(t)$, then plot and label the result. (Remember to multiply by the time step size if you use the **conv()** function.) Affix a copy of the graph to your lab book.

Add a MATLAB function to your script that computes the system's transfer function, $H(j\omega) = P(j\omega)/Q(j\omega)$. Compute $F(j\omega)$, the Fourier transform of $f(t)$ analytically (using Table 4.1 of the text and the properties of the Fourier Transform), and write a MATLAB function that computes $F(j\omega)$.

Find y(t) by numerically integrating:

$$y(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(j\omega)H(j\omega)\, e^{j\omega t}\, d\omega$$

If **quadgk()** proves to be too slow, satisfactory results can be obtained by sampling $F(j\omega)$ and $H(j\omega)$ over the range $[-2\times10^6, 2\times10^6]$ then by using the function **trapz()**:

```
w = -2000000:2000:2000000;
for i = 1:length(y)
  y(i) = trapz(w,F(w).*H(w).*exp(1j*w*t(i)))/(2*pi);
end;
```

Plot and label $y(t)$. Verify that your result matches the $y(t)$ you obtained earlier. (Slight differences may arise because of the approximated integral.) Affix a copy of the graph to your lab book.

Procedure:

The goal of this laboratory procedure is to verify that the system response computed in the preliminary section matches reality. To do that, it will be necessary to configure the function generator to produce a triangle wave. This can be done by placing the generator in arbitrary waveform mode and editing an arbitrary waveform. To do this, press the *Arb* key, the *Edit* key, the *Operation* soft-key and the *Line* soft-key. By default, there are 1000 points in the waveform. The first 100 should be rising, the second 100 should be falling, and the last 100 should be 0. Enter these line segments one at a time, pressing the *Execute* soft-key after each.

X1	Y1	X2	Y2
1	0	100	16382
100	16382	200	0
200	0	1000	0

Table 1 – Line Segments

Configure the function generator to produce triangle pulses at 1kHz. (The 1ms period gives the system sufficient time for the response to decay between pulses). Adjust the low and high voltage levels to 0V and 10V respectively.

Assemble the circuit shown in Figure 1.

Make sure the oscilloscope probe is set to x10 and attach it to the output of the system. Verify that the response shown on the oscilloscope matches the responses you computed earlier. Sketch the oscilloscope output into your lab book, making note of both the horizontal and vertical scales.

Repeat the entire process for $f(t) = \text{rect}\left(\frac{t-10^{-4}}{2\times10^{-4}}\right)$ as shown in Figure 3.

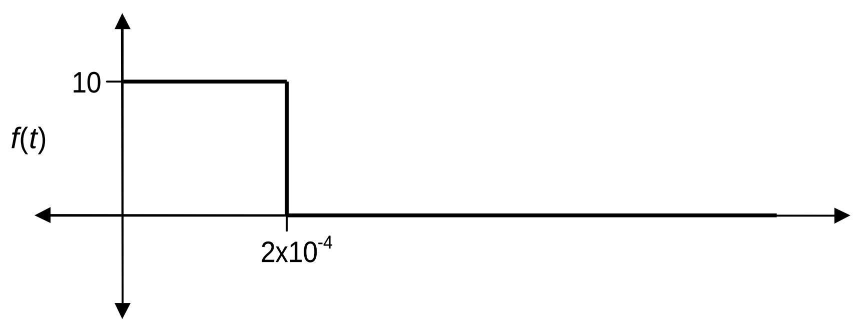

Figure 3. Input (Stimulus) Signal #2

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