Step and Impulse Response of a RLC Band Pass Filter

Lab 5

Spring 2021

1 Purpose

Use Laplace transforms to find the time-domain response of an RLC bandpass filter to impulse and step inputs.

2 Deliverables Overview

2.1 Part 1

- Two plots that should be identical to each other to be included in the **Data** section of your report.

2.2 Part 2

- One plot to be included in the **Data** section of your report.
- Properly formatted equation for the final value theorem to be included in the **Equations Used** section of your report.

As usual, plots and equations need to be thoroughly discussed in your report.

3 Part 1

3.1 Purpose

In this part of the lab, you will plot the impulse response of the circuit given in the prelab in two ways:

1. Using the hand-solved time-domain impulse response from the prelab, implemented as a function.
2. Using the `scipy.signal.impulse()` function with the s-domain transfer function from the prelab.

3.2 Deliverables

1. The two plots generated from your code. One figure with two subplots is the best way to plot these. Make sure the x and y axes are the same for both plots.

3.3 Tasks

Note: Both plots from this section should be identical.

1. Plot the impulse response $h(t)$ that you found by hand in the prelab assignment from $0 \leq t \leq 1.2$ ms.

2. Use the `scipy.signal.impulse()` function to plot the results from $0 \leq t \leq 1.2$ ms.

3.3.1 Example Code

The following code implements the Laplace domain transfer function $H(s) = \frac{s+2}{s^2+3s+8}$.

```
import scipy.signal as sig
t = np.arange(0, 1.2e-3+steps, steps) #This might already be defined in your code

num = [0, 1, 2] #Creates a matrix for the numerator
den = [1, 3, 8] #Creates a matrix for the denominator

tout, yout = sig.impulse((num, den), T = t)

#Plot tout, yout
```

4 Part 2

4.1 Purpose

This section uses `scipy.signal.step()` function to plot the step response of the transfer function $H(s)$. Additionally, the final value theorem will be demonstrated.

4.2 Deliverables

The plot from this section and discussion on the final value theorem.

4.3 Tasks

1. Find the step response of $H(s)$ using the `scipy.signal.step()` function from $0 \leq t \leq 1.2$ ms.

2. Perform the final value theorem for the step response $H(s)u(s)$ in the Laplace domain. The results need to be included in your report and properly formatted.

3. Compare your result to the plot in **Part 1** *Task 2* and discuss whether your result makes sense.

5 Questions

1. Explain the result of the Final Value Theorem from **Part 2** *Task 2* in terms of the physical circuit components.

2. Leave any feedback on the clarity of the expectations, instructions, and deliverables.

$$\lim_{t\to\infty}\{h(t)\} = \lim_{s\to 0}\{H(s)\cdot s\}$$

If all poles are in the LHP.

$$H(s) = \frac{L\cdot s}{R\cdot L\cdot C\cdot s^2 + L\cdot s + R}$$

As all poles are in LHP, the FVT is valid.

$$\lim_{s\to 0}\{H(s)U(s)\cdot s\} =$$

$$\lim_{s\to 0}\left\{\frac{s}{s}\cdot\frac{L\cdot s}{RLCs^2 + L\cdot s + R}\right\} = \left.\frac{Ls}{RLCs^2 + L\cdot s + R}\right|_{s\to 0}$$

$$\Rightarrow \lim_{s\to 0}\{H(s)U(s)\cdot s\} = 0.$$

These results fit what is seen in the plot of Part 2 Task 4.