ECE 351 - Section 53

# Step and Impulse Response of an RLC Band Pass Filter

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# Lab 5

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# Contents

# 1 Introduction

The objective of this lab was to utilize Laplace transforamtions in order to find the time-domain response of an RLC bandpass filter to the step and impulse inputs.

The code for this project can be found at the below github repository.

GitHub: `https://github.com/Chadwick-g`

# 2 Equations

Transfer Function:

$$H(s) = \frac{LS}{LRCS^2 + LS + R} \tag{1}$$

Impulse Response:

$$h(t) = 10000e^{(-5000t)}[cos(18584t) - 0.269sin(18584t)] \tag{2}$$

Final Value Theorem of H(S)u(S):

$$Lim_{s->0}(S * H(S) * u(S)) = Lim_{s->0}(S\frac{1}{S}\frac{LS}{LRCS^2 + LS + R}) = 0 \tag{3}$$

# 3 Methodology

For this lab I utilized the scipy.signal.impulse function in order to verify that the hand calculated impulse response of the RLC bandpass filter was correct. The following code snippet captures everything necessary for calculating and verifying the hand calculation.

```
steps = 1e-6
t = np.arange(0, 0.0012+steps, steps)

num = [0, .027, 0]
den = [1000*.027*(10**-7), .027, 1000]
h_t = 10000*np.exp(-5000*t)*(np.cos(18584*t)-0.269*np.sin(18584*t))
tout, yout = sig.impulse((num,den), T=t)
```

In order to properly plot the function correctly using pyplot, it was necessary to scale down the step size used, in order to account for the rather small interval that the response occurs over.

Moving forward, I then used the scipy.signal.step function in order to find the step response, utilizing the transfer function. The code below encapsulates how this was accomplished in its simplicity.

```
lti = sig.lti(num,den)
tout, yout = sig.step(lti)
```

# 4 Results

Below are the resulting graphs that I constructed for this lab.

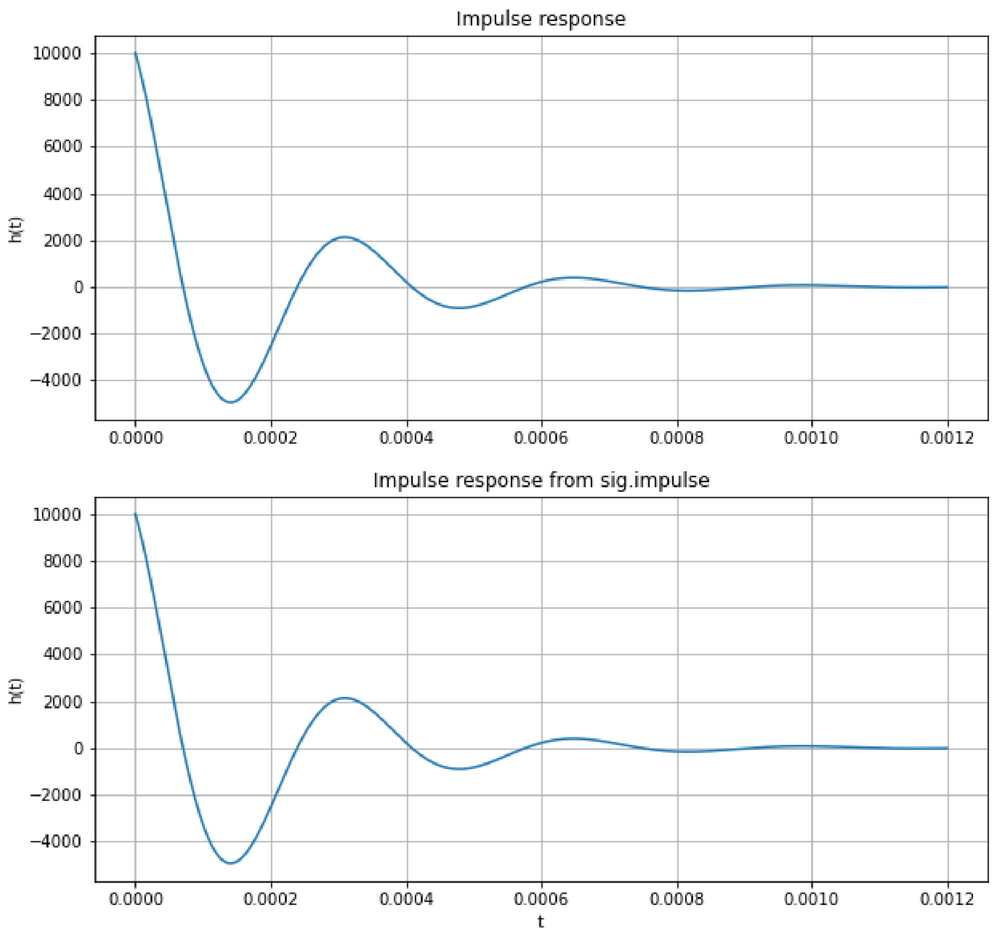


Figure 1: Impulse response

Here it can be observerd that the two impulse response graphs from the hand solved equation as well as the the scipy.signal.impulse function are Identical as they should be, indicating the hand solved equation was in fact correct.

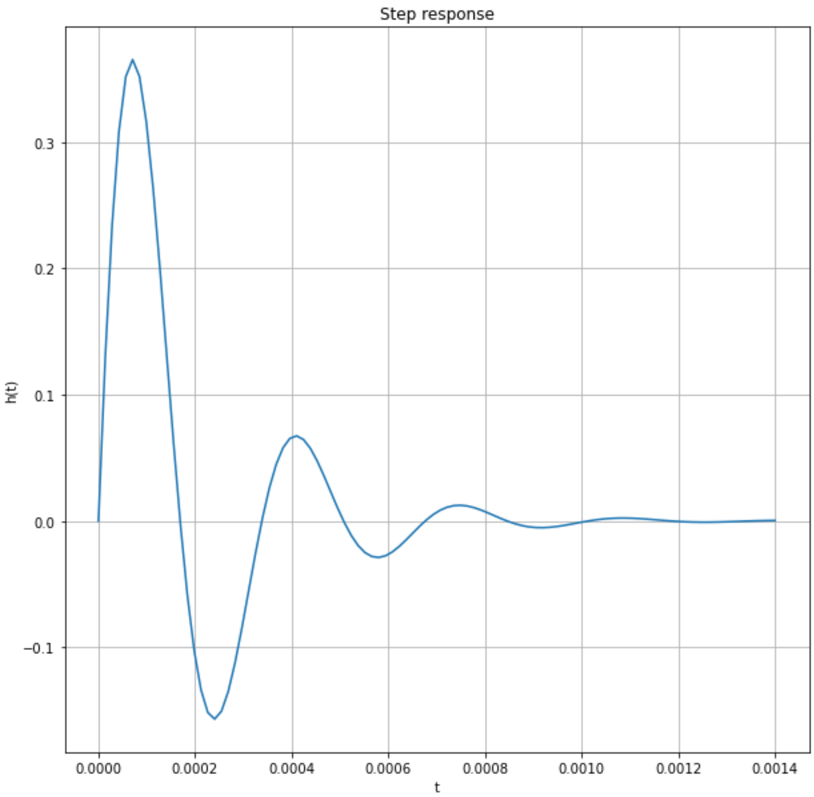


Figure 2: Step response

Analyzing the above graph, generated by the signal.step function it can be seen that the system oscillates until finally arriving at a final value of zero. When comparing to the result attained from applying the Final Value Theorem on the step response this intuitively makes sense seeing as the result also settles at the value of zero. As a result it can be concluded that this verifies my hand calculation of the FVT.

# 5 Error Analysis and Difficulties

There were no extremely challenging parts to this lab besides reading the documentation and figuring out how to use the step and impulse functions.

# 6 Questions

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

In terms of real world circuit components the Final Value Theorem result from the previous section represents the settling oscillation of a system. This can be described as the stability of the system, which in this case the system is stable and therefore, if this were a circuit component, it could be compared to something such as the diminishing current through an inductor as it loses energy. Furthermore it can be compared to the diminishing voltage of a capacitor as it discharges over time.

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

This was another simple and straightforward lab.

# 7 Conclusion

Concluding this lab I feel like I am definitely understanding the utility and usefulness of Laplace transforms to solve for various responses of a system as it makes calculations significantly more simple.