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Course: ECE 3210

Subject: Lab 5, LTI System Response to Periodic Signal

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1 Introduction

In this lab, we explore an LRC circuit system's response to periodic signals, combining theoretical analysis and practical implementation. Using Fourier series analysis, we break down input signals into exponential components. Practical experiments involve constructing the LRC circuit system, connecting it to a signal generator, and comparing observed results with theoretical predictions.

2 Theory

We aim to represent a square wave signal, as described in Fig. 1, using a complex exponential Fourier series. The square wave has an amplitude of 4 V, no DC component, and a frequency of 20 kHz. To accomplish this, we express the square wave as a sum of complex exponential components. The complex exponential Fourier series representation of the square wave $f(t)$ is given by:

$$f(t) \approx \sum_{n=-m}^{m} D_n e^{jn\omega_0 t} \tag{1}$$

Where D_n represents the Fourier coefficients, and $\omega_0 = 4 \times 10^4 \pi$ is the angular frequency for 20 kHz. We will analyze this representation with 35 harmonics. Where D_n is given by:

$$D_n = \frac{1}{T_0} \int_{T_0} f(t) e^{-jn\omega_0 t}\, dt \tag{2}$$

Solving for D_n yields:

$$D_n = \frac{8 \sin\left(\frac{n\pi}{2}\right)}{n\pi} \tag{3}$$

We also needed to find the ODE governing the circuit in Fig. 1 and derive the transfer function. Doing so yields:

$$H(s) = \frac{\frac{s}{RC}}{s^2 + \frac{s}{RC} + \frac{1}{LC}} \tag{4}$$

Subsequently, y(t) is given by:

$$y(t) = \sum_{n=-\infty}^{\infty} H(jn\omega_0) D_n e^{jn\omega_0 t} \tag{5}$$

3 Results

The results of this lab, shown in Fig. 2 highlight our findings. Initially, our lab data exhibited a phase shift compared to the theoretical values. To rectify this issue, a phase shift was introduced, aligning our results more closely with the expected outcomes. The lab values also exhibited a larger amplitude than our theoretical values.

4 Discussion and Conclusions

Originally our measured response was out of phase with the theoretical response. To align both responses I shifted the measured values by 22 microseconds. The measured values also display a slightly larger amplitude, both of these discrepancies are probably caused by tolerances in the parts we used.

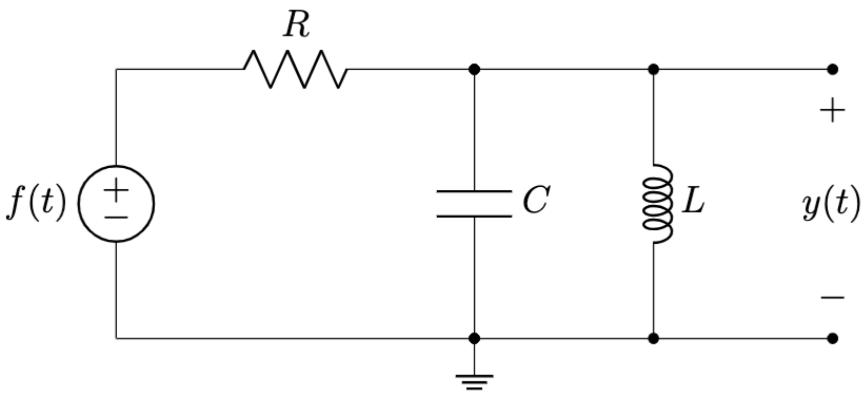

Figure 1: Shown here is the circuit we were given to analyze.

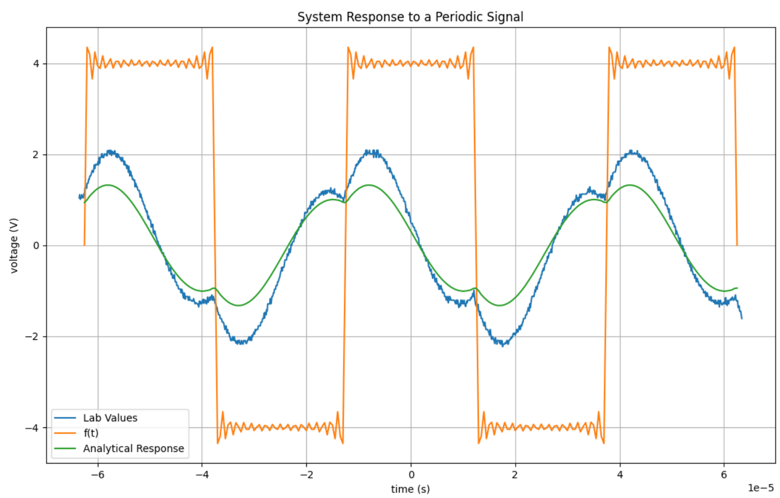

Figure 2: This figure shows the system response to a periodic signal for the theoretical response as well as the measured response. Included is also the input signal.