# Abdullah Gül University

## Department of Electrical and Electronics Engineering

# Pre-Lab 4

## RLC Circuit Phasor Analysis

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# Contents

# Chapter 1

# Overview

## 1.1 Objective

This pre-lab report focuses on analyzing and simulating an RLC circuit, as shown in Figure 1. The circuit is described by the equation $V_R + V_L = 2\cos(\omega t - 7.5)$ with a frequency of $f = 1kHz, \omega = 2\pi \times 10^3 \frac{\text{rad}}{\text{s}}$. The objectives include calculating the capacitor value $C$ and determining the phasor-domain voltage and current values ($V_C$, $I_i$, and $I_o$). Additionally, the circuit will be simulated in LTspice to observe the waveforms for voltages $V_C$ and $V_L$, as well as currents $I_i$ and $I_o$.

# Chapter 2

# Procedure

## 2.1 Analytical Calculations in Phasor Domain

### 2.1.1 Determine the Capacitor Value

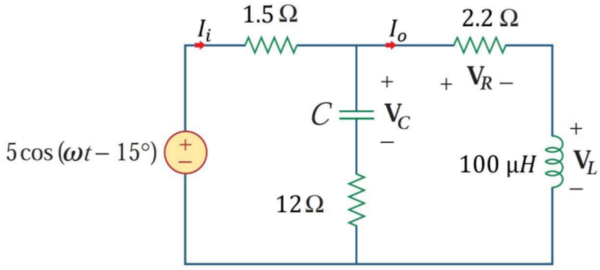


Figure 2.1: RLC Circuit

Transforming this circuit into the phasor domain, we have the following circuit:

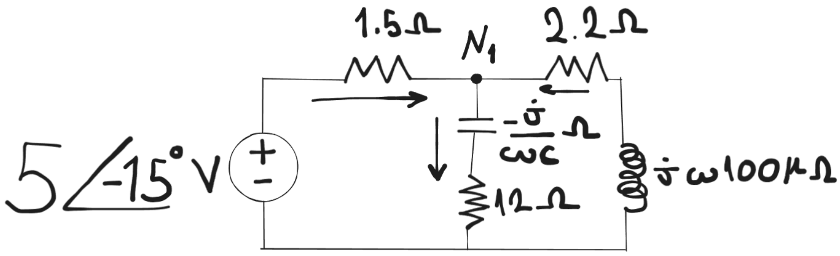


Figure 2.2: RLC Circuit Phasor Domain

Applying nodal analysis at node $N_1$:

$$\frac{V_S - N_1}{1.5} + \frac{N_1}{2.2 + j2\pi \times 10^{-1}} - \frac{N_1}{12 + \frac{-j}{2000\pi C}} = 0 \tag{2.1}$$

$V_S$ and $N_1$ are given as $V_S = 5\angle{-15^\circ}$ and $N_1 = 2\angle{-7.5^\circ}$.

Solving for $C$:

$$\frac{5\angle -15^\circ - 2\angle -7.5^\circ}{1.5} + \frac{2\angle -7.5^\circ}{2.2 + j2\pi \times 10^{-1}} - \frac{2\angle -7.5^\circ}{12 + \frac{-j}{2000\pi C}} = 0 \tag{2.2}$$

$$\frac{5\angle -15^\circ - 2\angle -7.5^\circ}{1.5} + \frac{2\angle -7.5^\circ}{2.2 + j2\pi \times 10^{-1}} = \frac{2\angle -7.5^\circ}{12 + \frac{-j}{2000\pi C}} \tag{2.3}$$

$$2.0189\angle -19.9451^\circ + 0.8741\angle -23.4393^\circ = \frac{2\angle -7.5^\circ}{12 + \frac{-j}{2000\pi C}} \tag{2.4}$$

$$2.8919\angle -21.0007^\circ = \frac{2\angle -7.5^\circ}{12 + \frac{-j}{2000\pi C}} \tag{2.5}$$

$$\frac{-j}{2000\pi C} = \frac{2\angle -7.5^\circ}{2.8919\angle -21.0007^\circ} - 12 = 11.3287\angle 179.1834^\circ \tag{2.6}$$

$$C = \frac{-j}{2000\pi \times 11.3287\angle 179.1834^\circ} = 1.4049\angle 90.8166^\circ = -200.2236\times 10^{-9} + j14.0474\times 10^{-6} \tag{2.7}$$

From equation 2.7, we have $C = -200.2236 \times 10^{-9} + j14.0474 \times 10^{-6}$, which means there should be a capacitor with a real value which is impossible. Therefore, we can add a $200.2236 \times 10^-9\Omega$ resistor in series to the capacitor to make it only capacitive. After that, the capacitor value is $j14.0474\mu\Omega$.

### 2.1.2 Calculating Voltage and Current Values

After finding the capacitor value, we know everything about the circuit. We can calculate the Voltage and current values as follows:

$$I_O = \frac{2\angle -7.5^\circ}{2.2 + j2\pi \times 10^{-1}} = 0.802\angle -3.4771^\circ A \tag{2.8}$$

$$I_i = \frac{5\angle -15^\circ - 2\angle -7.5^\circ}{1.5} = 2.0189\angle -19.9451^\circ A \tag{2.9}$$

$$I_C = I_i - I_O = 1.2703\angle -30.255^\circ A \tag{2.10}$$

And from the current values, we can calculate the voltage values:

$$V_R = I_O \times 2.2 = 1.7644\angle -3.4771^\circ V \tag{2.11}$$

$$V_L = I_O \times j2\pi \times 10^{-1} = 0.50391\angle 86.5229^\circ V \tag{2.12}$$

$$V_C = I_C \times j14.0474\mu = 1.7844\angle 59.745^\circ V \tag{2.13}$$

Converting the phasor voltages and currents to time domain:

$$v_R(t) = 1.7644\cos(2000\pi t - 3.4771°)V \tag{2.14}$$

$$v_L(t) = 0.50391\cos(2000\pi t + 86.5229°)V \tag{2.15}$$

$$v_C(t) = 1.7844\cos(2000\pi t + 59.745°)V \tag{2.16}$$

$$i_O(t) = 0.802\cos(2000\pi t - 3.4771°)A \tag{2.17}$$

$$i_i(t) = 2.0189\cos(2000\pi t - 19.9451°)A \tag{2.18}$$

$$i_C(t) = 1.2703\cos(2000\pi t - 30.255°)A \tag{2.19}$$

## 2.2 SPICE Simulation

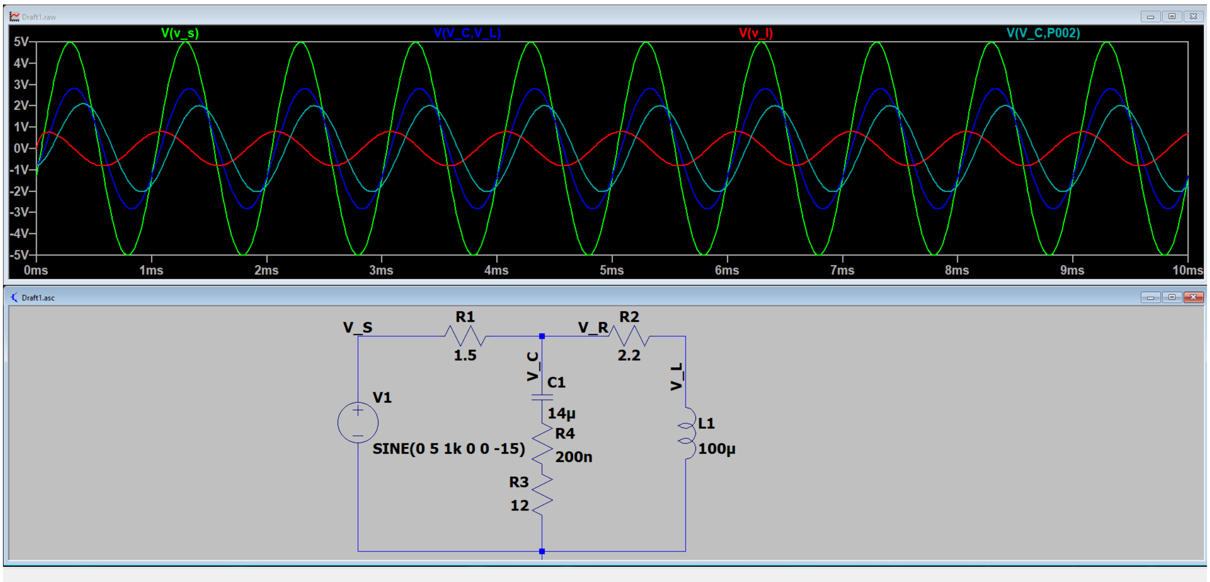


Figure 2.3: SPICE Voltage Simulation

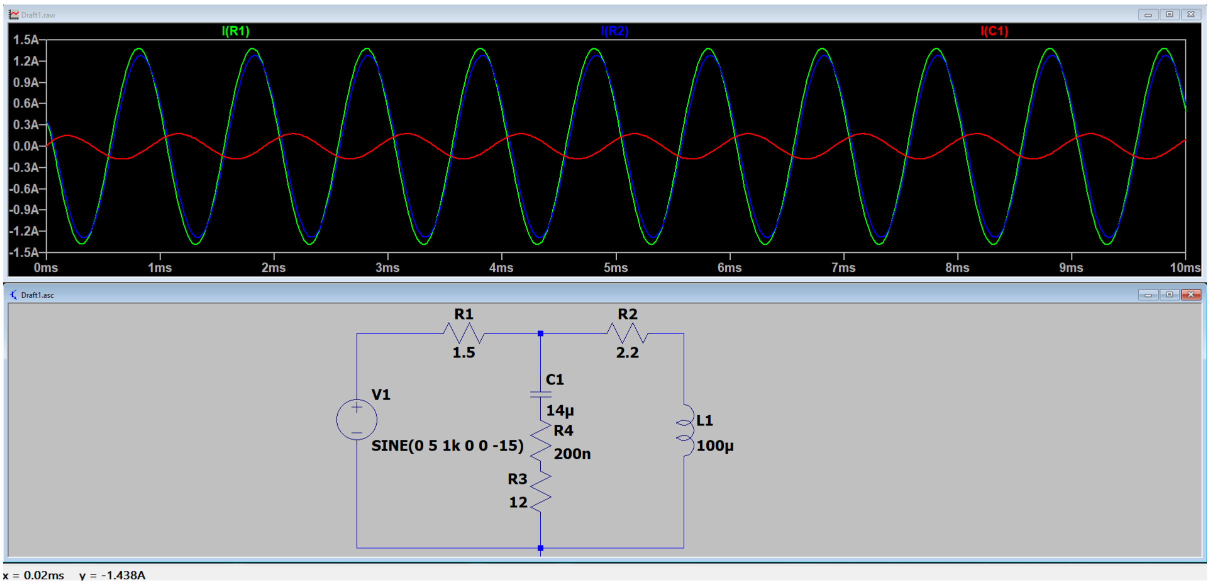


Figure 2.4: SPICE Current Simulation

Comparing the SPICE simulation results with the analytical calculations, everything seems to be correct.

# Chapter 3

# Discussion

## 3.1 Analytical Results

The calculated capacitor value, voltage, and currents and are based on phasor-domain principles. These results highlight the phase differences and magnitude relationships inherent in RLC circuits operating at a specific frequency.

## 3.2 Simulation Analysis

The SPICE simulation provides a practical visualization of the circuit's behavior. Waveforms for and demonstrate the phase shifts due to the reactive components, while and reflect the current distribution through the circuit.

# Chapter 4

# Conclusion

This pre-lab exercise has provided a comprehensive approach to understanding RLC circuit dynamics. By combining phasor-domain analysis with SPICE simulations, we have:

- Determined the capacitor value required for circuit functionality.
- Calculated key voltage and current parameters.
- Visualized the circuit's behavior through simulation.

These steps ensure **readiness for the lab experiment** and a deeper understanding of the theoretical and practical considerations of RLC circuits.