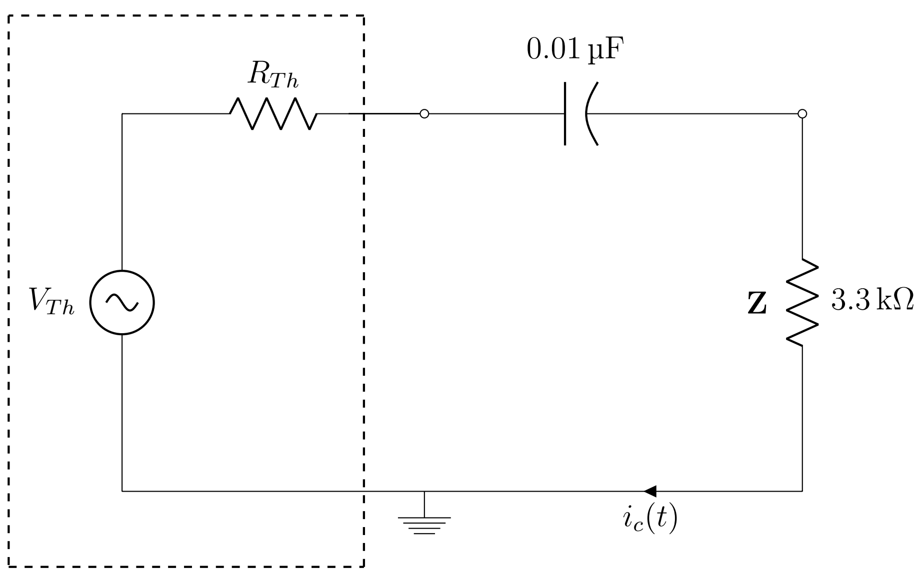
Objectives

- To examine the sinusoidal-steady-state response of simple-series RL and RC circuits
- To investigate the effect of frequency variations on the amplitude and phase angle of the SSS response of the RC and RL circuits

Procedure

Part I: The Sinusoidal-Steady-State Behaviour of an RC Circuit

1. Connect channel 1 of the oscilloscope across the output of the terminals of the function generator. Set the controls of the function generator to provide an open circuit sinusoidal voltage of 5V (peak) a frequency (f) of 500Hz
2. Connect the circuit shown in the figure below. Set the oscilloscope for an ac-coupling, Y-position screen centre, Trigger source channel 1, and Trigger Slope Rising. Connect channel 1 of the oscilloscope to display the voltage waveform node (A), and channel 2 to display the voltage waveform node (B).
3. Measure the peak-value of $\mathbf{v}_A\mathbf{(t)}$ and $\mathbf{v}_B\mathbf{(t)}$, and record in table 1 under $|V_A|$ and $|V_B|$ respectively. Evaluate the peak value of the current $|\mathbf{I}_C|$



4. Measure the phase angle θ, and evaluate the magnitude of $|\mathbf{Z}|$ & phase angle θ_Z of the impedance of $\mathbf{Z}$. Record your results in the first table.

5. Repeat the steps above for each frequency in table 2.

6. Use the semi-logarithmic graph to plot $|\mathbf{Z}|$ & θ_Z vs frequency.

Part II: The Sinusoidal Steady State Behaviour of an RL Circuit

6. Replace the capacitor in your circuit with the decade-resistance box ($\mathbf{L} = \mathbf{0.5H}$). Use the oscilloscope to measure $|\mathbf{V}_A|$, $|\mathbf{V}_B|$, and θ for each of the frequencies listed in the table below. Evaluate $|\mathbf{I}_L|$, and the magnitude $|\mathbf{Z}|$ with the phase angle θ_Z of the impedance $\mathbf{Z}$.

7. Use the semi-logarithmic graph 1 to plot $|\mathbf{Z}|$ and θ_Z vs frequency.

Data

Table (6.3)

frequency (kHz)	$\lvert\mathbf{V}_A\rvert$(V)	$\lvert\mathbf{V}_B\rvert$(V)	$\lvert\mathbf{I}_C\rvert$(mA)	$\lvert\mathbf{Z}\rvert$(kΩ)	$\lvert\theta_Z\rvert$
0.5	5.0	0.50	0.152	33.0	-105.7
1	5.0	1.0	0.303	16.5	-86.4
2	5.0	1.6	0.485	10.3	-82.4
5	5.0	3.4	1.03	4.85	-46.8
10	5.0	4.5	1.36	3.67	-28.8
20	5.0	4.9	1.48	3.37	-14.4
50	5.0	5.0	1.52	3.30	-1.8

Table (6.4)

frequency (kHz)	$\lvert\mathbf{V}_A\rvert$(V)	$\lvert\mathbf{V}_B\rvert$(V)	$\lvert\mathbf{I}_C\rvert$(mA)	$\lvert\mathbf{Z}\rvert$(kΩ)	$\lvert\theta_Z\rvert$
0.1	5.1	4.04	1.22	4.17	3.9
0.2	5.1	4.00	1.21	4.21	10.4
0.5	5.1	3.76	1.14	4.48	22.8
1	5.1	3.26	0.988	5.16	37.6
2	5.1	2.26	0.685	7.45	57.2
5	5.1	1.08	0.327	15.6	84.0
10	5.1	0.56	0.170	30.1	84.0

Graphs are attached ahead.

Conclusion

1. From Graph 6.1, it is observed that the frequency and magnitude of impedance are inversely proportional. The impedance decreases exponentially as frequency increases. Contrastingly, the phase shift vs frequency graph is exponentially proportional. The impedance is predominantly resistive between the frequencies if 10kHz and 50kHz, while it is predominantly capacitive between 0.5kHz and 10kHz.

2. The phase angle vs frequency, and magnitude of impedance vs frequency of a parallel and RC circuit are all directly proportional. As the frequency increased, both the magnitude of the impedance and the phase angle increases exponentially. The impedance is predominantly capacitive when frequencies are high, and predominantly resistive when frequencies are low.The phase vs frequency graph of a parallel RC circuit will be a vertically inverted phase vs frequency graph of the RC series circuit

3. From graph 6.2, it is observed that the frequencies and magnitude are exponentially proportional. It is also observed that phase shift vs frequency are exponentially proportional. The positive sign of the phase angle shows that the voltage leads current. The impedance is predominantly inductive between frequencies of 0.5kHz to 10kHz, and it is predominantly resistive between frequencies of 0.1kHz to 0.5kHz.

4. The phase vs frequency graph od a parallel RL circuit will be a vertically inverted phase and frequency of the series RL circuit.

5.

$$\begin{aligned}
i_c(t) &= 4\cos(2\pi \cdot 2000t + 20^\circ) \\
v_{RC}(t) &= \frac{i_c(t)}{j\omega C} \\
v_{RC}(t) &= \frac{4\underline{/20^\circ}}{j(2000 \cdot 2\pi)C}
\end{aligned}$$

$$\begin{aligned}
i_c(t) &= 3\sin(2\pi \cdot 5000t - 30^\circ) \\
v_{RC}(t) &= \frac{i_c(t)}{j\omega C} \\
v_{RC}(t) &= \frac{3\underline{/-30^\circ}}{j(5000 \cdot 2\pi)C}
\end{aligned}$$

6.

$$
\begin{aligned}
v_{RL}(t) &= 4\cos(2\pi \cdot 2000t + 20^\circ) \\
i_L(t) &= \frac{v_{RL}}{j\omega L} \\
i_L(t) &= \frac{4\underline{/20^\circ}}{j(2000 \cdot 2\pi)}
\end{aligned}
$$

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i_L(t) &= \frac{3\underline{/20^\circ}}{j(5000 \cdot 2\pi)}
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$$