LAB 3: RC FILTER AND SERIES RLC CIRCUIT

1. Goals

- Design, implement, and investigate the properties of RC filters.
- Design, simulate, and investigate the properties of a series RLC circuit.

2. Exercises

Exercise 1. Investigate a lowpass filter and a highpass filter with R, C components as shown in Figure 1. The cut-off frequency of both filters are determined by: $f_0 = \frac{1}{2\pi RC}$.

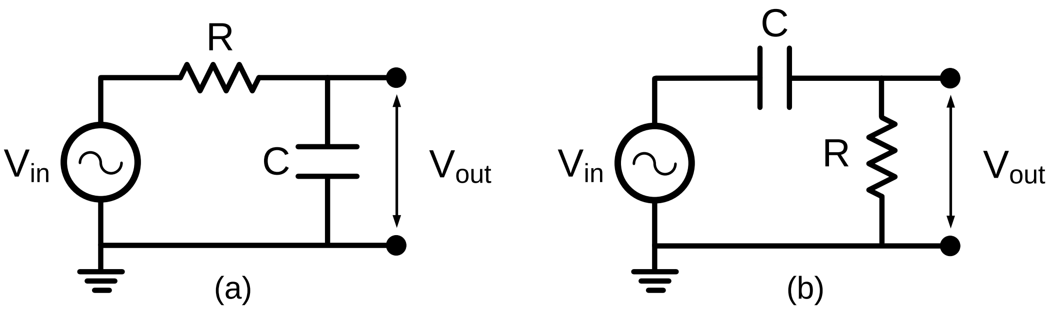

Figure 1. (a) Lowpass filter and (b) highpass filter.

Requirements:

a) Follow the steps below to investigate a lowpass RC filter:
   - Use the components given in the table to assemble the lowpass RC filter (Fig. 1(a)) on a breadboard.
   - Measure the real values of the resistor and capacitor used in the filter. Compare the measured values with the label value of each component.
   - Use a function generator to produce Vin (input voltage) for the circuit.
   - Use an oscilloscope to display Vin and $Vout$ (output voltage).
   - Set Vin = 5V (peak value) and its frequency = 1 kHz. Measure and record the amplitude of $Vout$.
   - Keep the amplitude of Vin fixed. Vary the frequency of Vin over a wide range (e.g., 1Hz, 10 Hz, 100 Hz, 10 kHz, 100 kHz). Measure and record the amplitude $Vout$. Comment on the obtained results. ***Notice:*** *You may use the button on the function generator to make sure that Vin = 5V.*
   - Based on the obtained value of $Vout$ corresponding to each frequency of Vin, plot the frequency response of the lowpass RC filter, with the vertical axis (*y-axis*) being the *gain* and the horizontal axis (*x-axis*) being the *frequency* (measured in dB).
   - Find the frequency of Vin at which $\frac{Amplitude\ of\ Vout}{Amplitude\ of\ Vin} = \frac{1}{\sqrt{2}} = 0.707$. Compare this frequency value with the cut-off frequency calculated by $f_0 = \frac{1}{2\pi \mathrm{RC}}$. Draw a conclusion.

- For a lowpass RC filter, the phase difference (or phase shift) between $Vout$ and Vin is calculated by $\varphi = -\arctan(2\pi fRC)$. At the cut-off frequency (such that $\frac{Amplitude\ of\ Vout}{Amplitude\ of\ Vin} = \frac{1}{\sqrt{2}} = 0.707$), use the oscilloscope to display the phase difference φ ($\varphi = -\frac{\Delta t}{T} \times 360^o$). Comment on the obtained results.

b) Investigate a highpass RC filter as shown in Fig. 1(b) by repeating the same above steps (which have been done for investigating a lowpass RC filter).

Exercise 2. Use Multisim Live or other open-source circuit simulators to investigate the properties of a series RLC circuit. (**Note:** *Students can assemble the circuit on a breadboard and then investigate it.*)

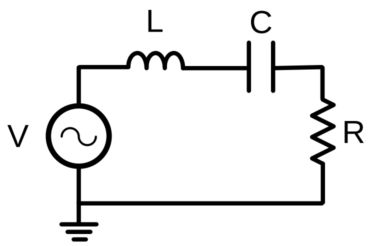

Figure 2. Series RLC circuit.

Requirements:

a) Implement the circuit as shown in Figure 2 with R = 330 Ω, L = 10 mH, C = 100 µF, $V = 5cos(2\pi 60t)\ (V)$.

b) Find the phase difference between V_R, V_L, V_C and V. Compare the simulation results with the theoretical calculation. Draw a conclusion.

c) Vary the frequency of the V (1 Hz~10 kHz) to find the resonant frequency (f_{MAX}) of the series RLC circuit (Note: V_R is maximum at f_{MAX}). Compare the simulation results with the theoretical calculation ($f_{MAX} = \frac{1}{2\pi\sqrt{RC}}$). Draw a conclusion.

Components and devices for exercises:

Components & Devices	Description	Amount
Ceramic Capacitor	223(0.022 µF), 104(0.1 µF), 106(10 µF)	1/1/1
Inductor	10 mH	1
Resistor	1 kΩ, 5 kΩ, 10 kΩ, 47 kΩ	1/1
Oscilloscope	OWON SDS1102	1
Function generator	UNI-T UTC962E	1
Power Supply	Aditeg PS-3030DD	1
Breadboard		1
Wires		Few
Multimeter		1