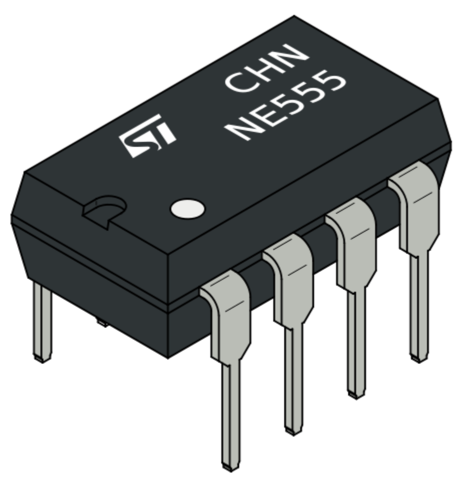
Report of Circuits Project: RL, RC and Port Network Using OrCAD

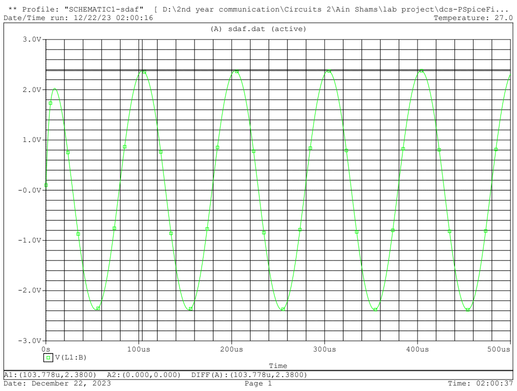
Team Data

Name	ID
Islam Ibrahim Mohamed	21010247
Ahmed Walid Hassan	21010205
Omar Mohamed AbdelMawgoud	21010887
Mohamed Elsayed Mohamed	21011097
Ahmed Mahmoud Farag	21010184

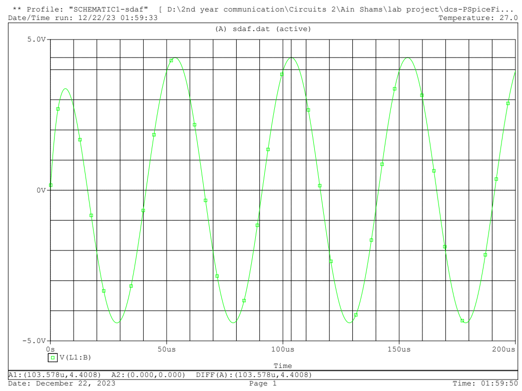


1 Lab-1: High Pass and Low Pass Filters

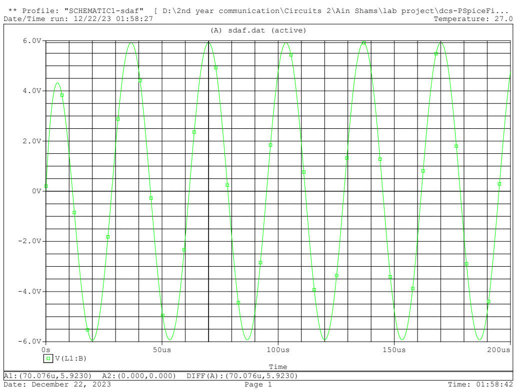
1.1 Voltages with Time plots with Frequency Change



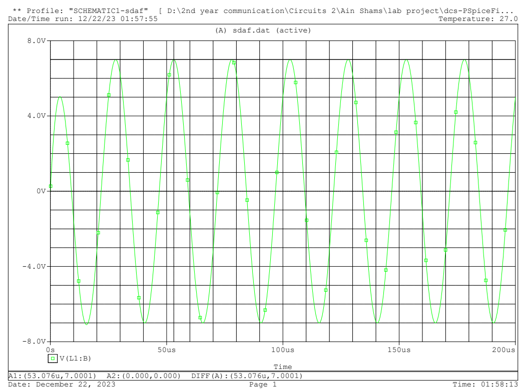
HPF 10 kHz



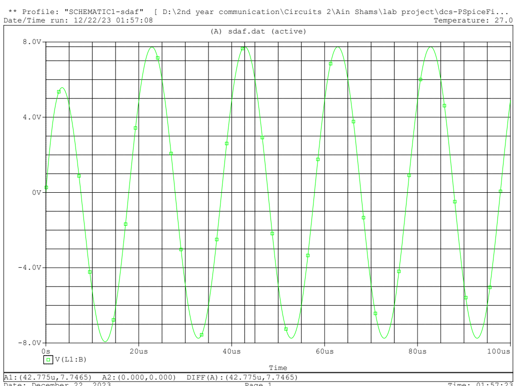
HPF 20 kHz



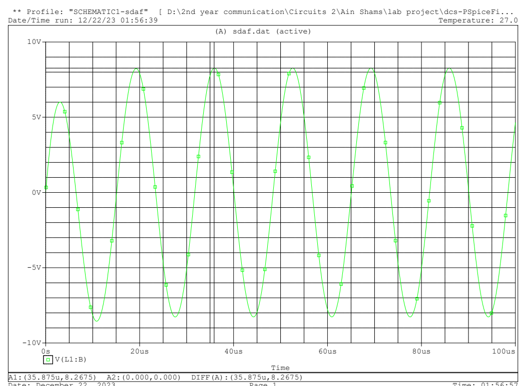
HPF 30 kHz



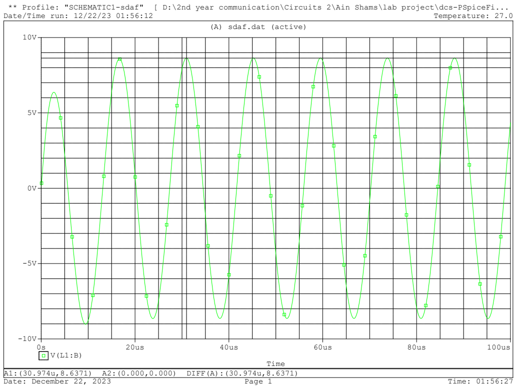
HPF 40 kHz



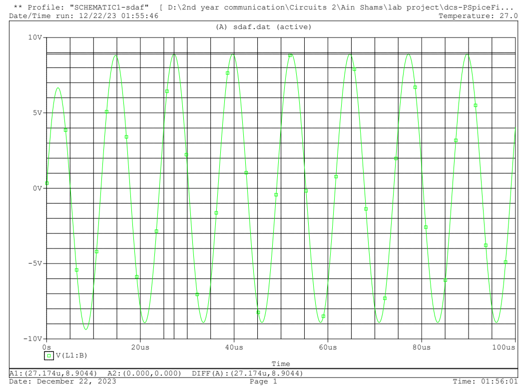
HPF 50 kHz



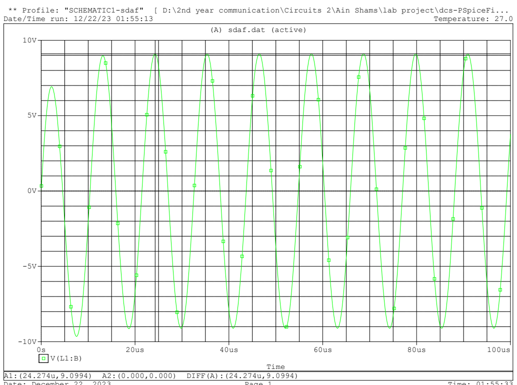
HPF 60 kHz



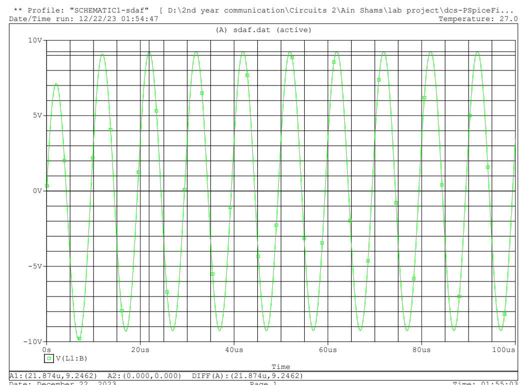
HPF 70 kHz



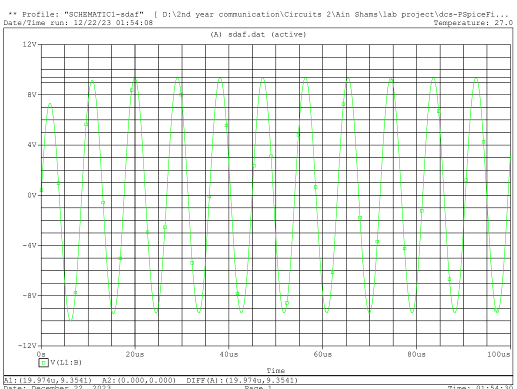
HPF 80 kHz



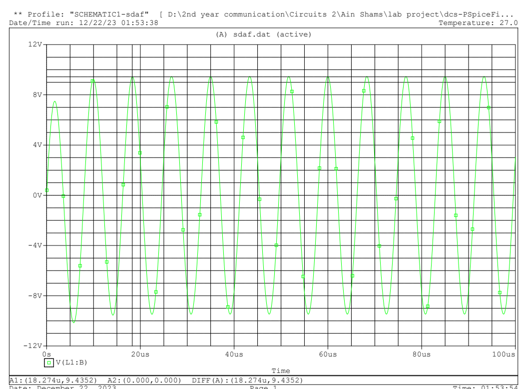
HPF 90 kHz



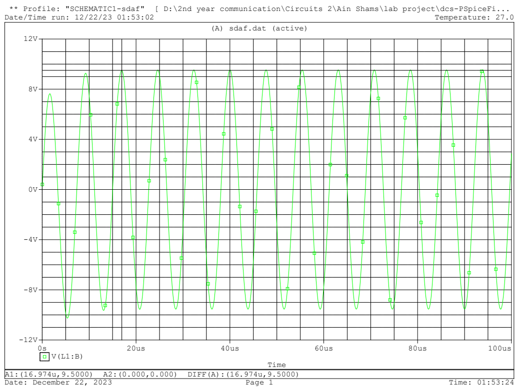
HPF 100 kHz



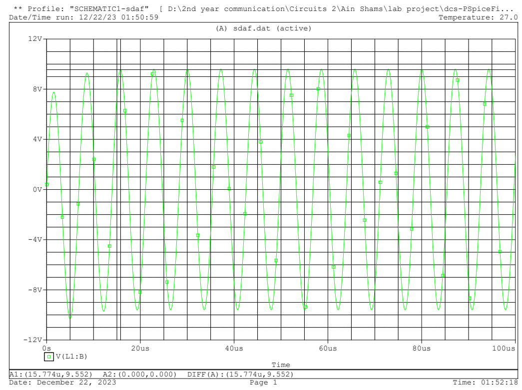
HPF 110 kHz



HPF 120 kHz



HPF 130 kHz



HPF 140 kHz

Voltages with Time plots for High Pass Filter

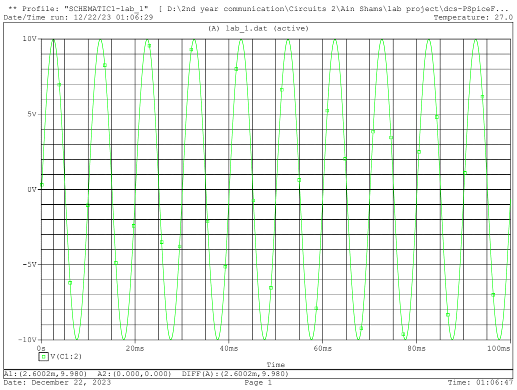
1.1.1 Discussion

Frequency(kHz)	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Voltage Gain(V_o/V_i)	0.23	0.44	0.59	0.7	0.77	0.83	0.86	0.89	0.91	0.92	0.935	0.94	0.95	0.96

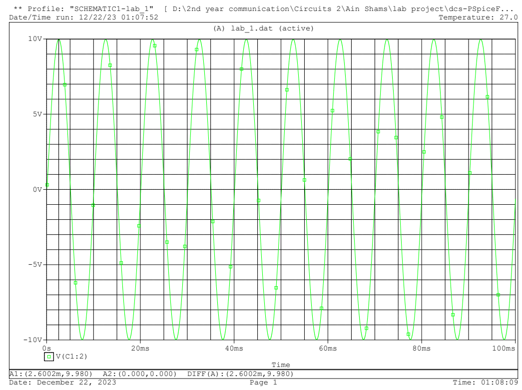
A high-pass filter (HPF) is a type of electric circuit that allows signals with frequencies higher than the cutoff frequency to pass through with minimal attenuation, while attenuating or blocking signals with frequencies lower than the cutoff frequency. The cutoff frequency of an HPF is determined by the specific design parameters of the filter, such as the values of resistor (R) and inductors (L).

The cutoff frequency of an HPF separates the low-frequency or "bass" signals from the high-frequency or "treble" signals. Signals below the cutoff frequency are attenuated or blocked, while signals above the cutoff frequency are passed through with minimal attenuation.

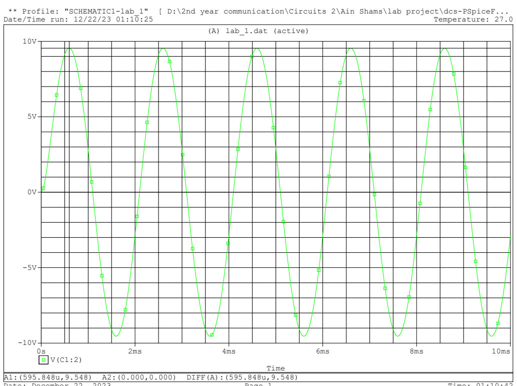
1.2 Voltages with Time plots with Frequency Change



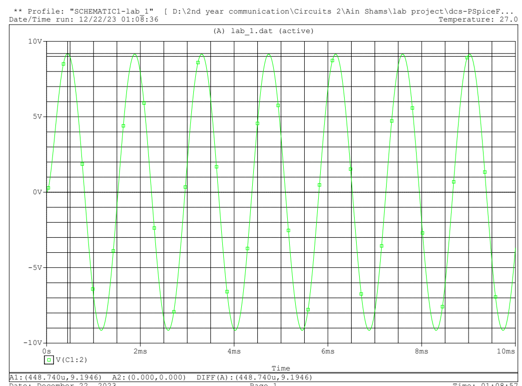
LPF 100 Hz



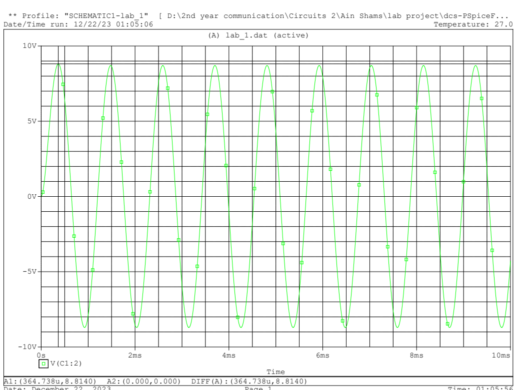
LPF 300 Hz



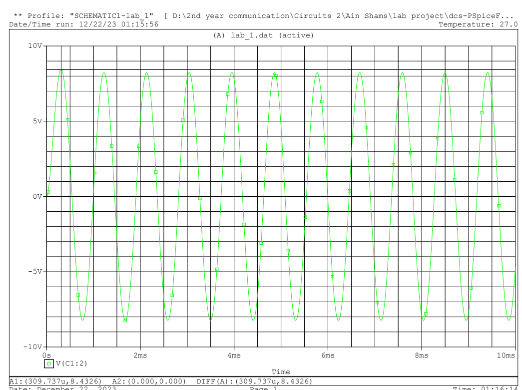
LPF 500 Hz



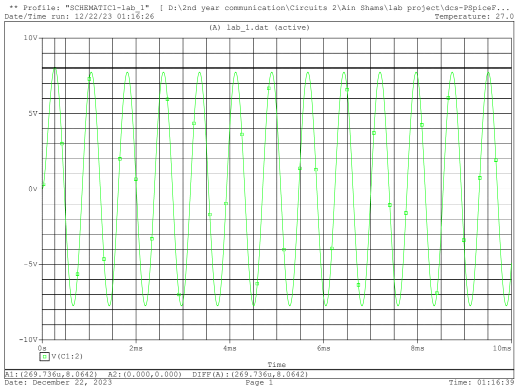
LPF 700 Hz



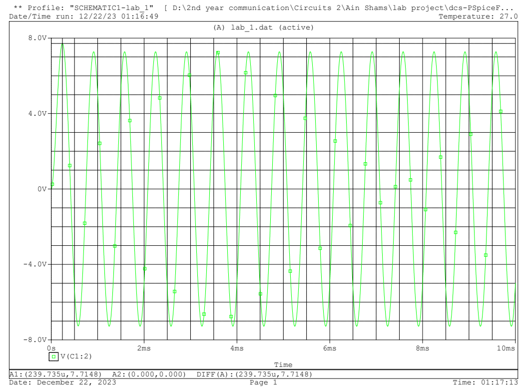
LPF 900 Hz



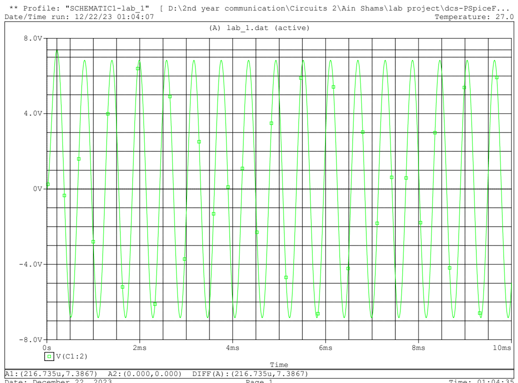
LPF 1100 Hz



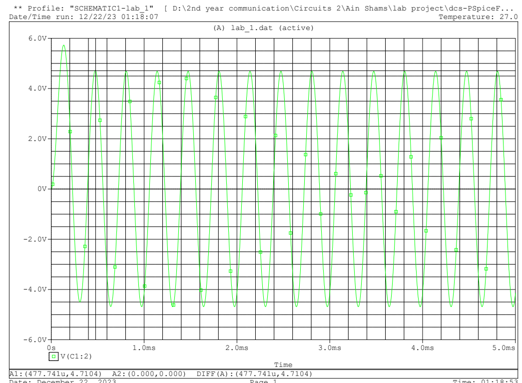
LPF 1300 Hz



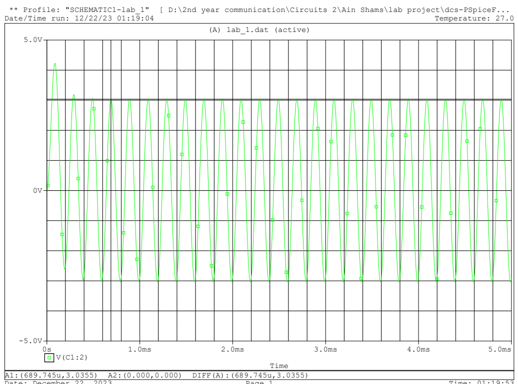
LPF 1500 Hz



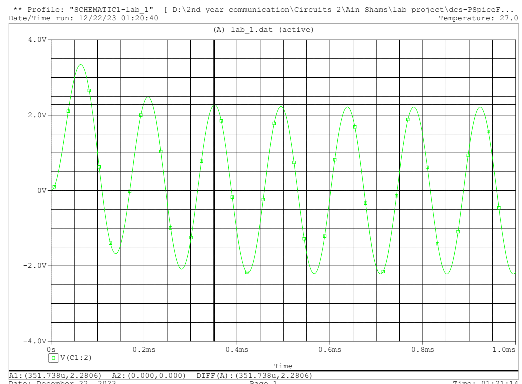
LPF 1700 Hz



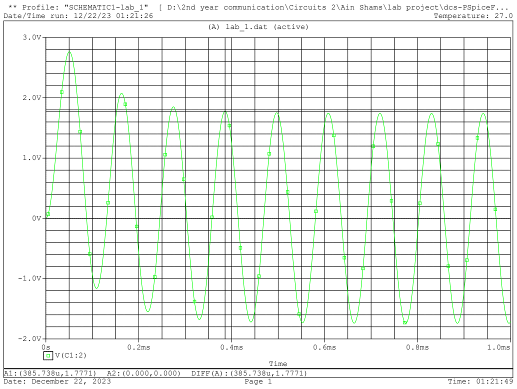
LPF 3 kHz



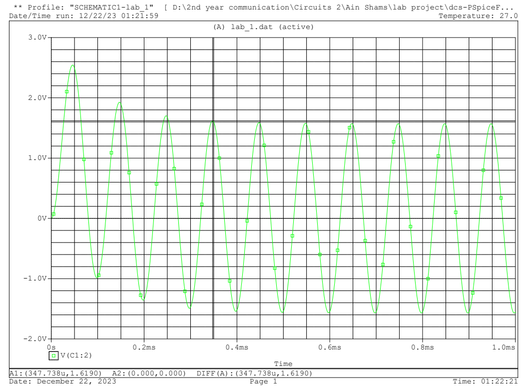
LPF 5 kHz



LPF 7 kHz



LPF 9 kHz



LPF 10 kHz

Voltages with Time plots for Low Pass Filter

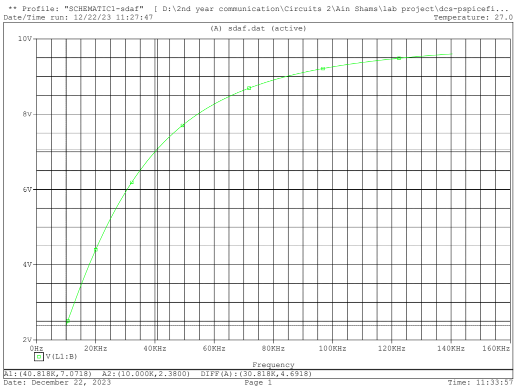
1.2.1 Discussion

Frequency(Hz)	100	300	500	700	900	1100	1300	1500	1700	3000	5000	7000	9000	10000
Voltage Gain(V_o/V_i)	0.99	0.99	0.95	0.92	0.88	0.84	0.8	0.77	0.73	0.47	0.3	0.22	0.17	0.16

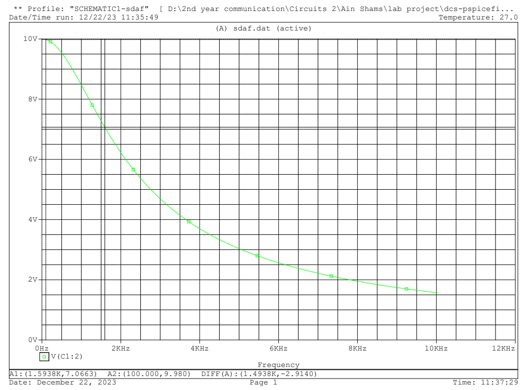
A low-pass filter (LPF) is a type of electric circuit that allows signals with frequencies lower than the cutoff frequency to pass through with minimal attenuation, while attenuating or blocking signals with frequencies higher than the cutoff frequency. The cutoff frequency of an LPF is determined by the specific design parameters of the filter, such as the values of resistors (R) and capacitors (C).

The cutoff frequency of an LPF separates the high-frequency or "treble" signals from the low-frequency or "bass" signals. Signals above the cutoff frequency are attenuated or blocked, while signals below the cutoff frequency are passed through with minimal attenuation.

1.3 Voltages with Frequency Change



High Pass Filter



Low Pass Filter

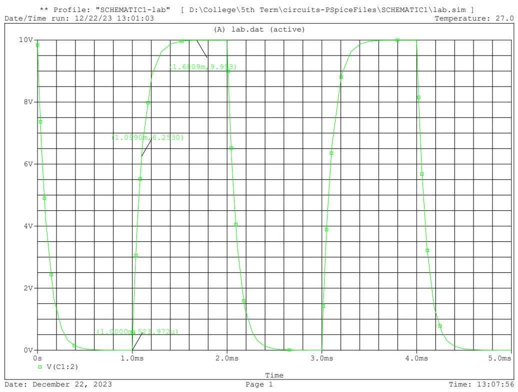
Voltages with Frequency plots

1.3.1 Discussion

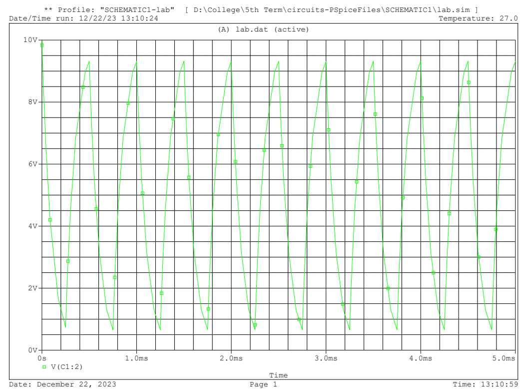
	Theoretical	Practical	Error
HPF	$f_c = \frac{R}{2\pi L} = \frac{1000}{2*\pi*3.9*10^{-3}} = 40.8kHz$	Gain $= \frac{1}{\sqrt{2}}$ of cut-off frequency $= 40.81kHz$	$0.01kHz$
LPF	$f_c = \frac{1}{2\pi RC} = \frac{1}{2*\pi*1000*0.1*10^{-6}} = 1.591kHz$	Gain $= \frac{1}{\sqrt{2}}$ of cut-off frequency $= 1.593kHz$	$0.02kHz$

2 Lab-2: Transit Response

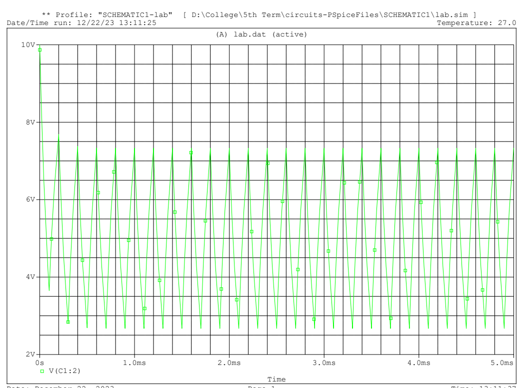
2.1 RC Response with Time plots with Frequency Change



RC Response in 500Hz



RC Response in 2kHz



RC Response in 5kHz

RC Response with Time plots

2.1.1 Discussion

An RC circuit is a combination of a resistor (R) and a capacitor (C) connected in series or parallel. When analyzing the transient behavior of an RC circuit, it involves studying the response of the circuit to changes in voltage or current over time.

Transient simulations of RC circuits are commonly used to study the charging and discharging processes of capacitors and to analyze the time-dependent behavior of signals in electronic circuits. The time constant (τ) of an RC circuit, which is the product of the resistance and capacitance ($\tau = R * C$), plays a crucial role in determining the transient response.

During the charging process, if a voltage is suddenly applied to the RC circuit, the capacitor gradually charges up to the input voltage level with an exponential time response.

$$V_C(t) = V_i * (1 - e^{-\frac{t}{\tau}})$$

The time it takes for the capacitor to charge to approximately 63.2% of the input voltage is equal to one time constant (τ). Similarly, during the discharging process, when the voltage source is suddenly removed, the capacitor discharges with an exponential decay.

$$V_C(t) = V_i * e^{-(\frac{t}{\tau})}$$

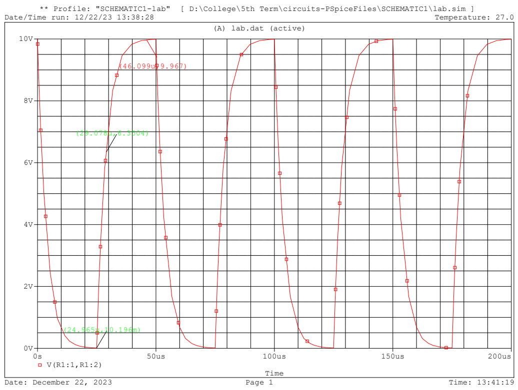
The transient response of an RC circuit is governed by various parameters such as the initial conditions (e.g., initial voltage across the capacitor), the input voltage, the resistance, and the capacitance. Transient simulations can be used to analyze and predict the behavior of RC circuits in various applications, induding signal processing, power electronics, and analog circuit design.

Calculating the time constant(t):

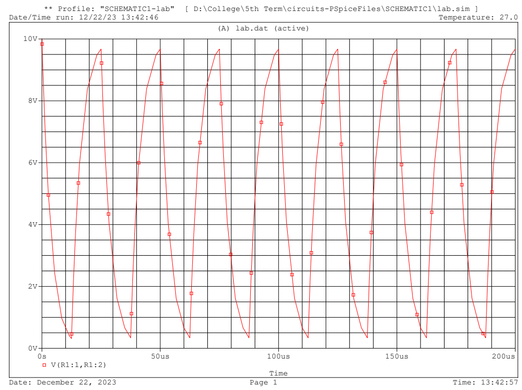
	Charging	Discharging
Theoretical (τ)	$\tau = RC = 100us$	$\tau = RC = 100us$
Practical (τ)	when $V_c = 10 * (1 - e^{-1}) = 6.32V$ then $\tau = 99us$	when $V_c = 10 * (e^{-1}) = 3.67V$ then $\tau = 99us$
Error (τ)	$1us$	$1us$
Theoretical (5τ)	$5\tau = 5RC = 500us$	$5\tau = 5RC = 500us$
Practical (5τ)	when it be stable $5\tau = 680us$	when it be stable $5\tau = 680us$
Error (5τ)	$180us$	$180us$

NOTE: we can notice that the output voltage attenuates by increasing the frequency of the input due to the LPF circuit as explained in the previous lab.

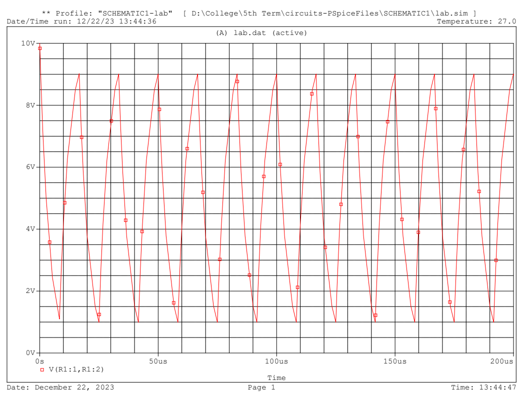
2.2 RL Response with Time plots with Frequency Change



RL Response in 20kHz



RL Response in 40kHz



RL Response in 60kHz

RL Response with Time plots

2.2.1 Discussion

An RL circuit is a combination of a resistor (R) and an inductor (L) connected in series or parallel. The transient simulation of an RL circuit involves studying the response of the circuit to changes in current or voltage over time.

Transient simulations of RL circuits are commonly used to analyze the behavior of inductors and to study the time-dependent response of signals in electronic circuits. The time constant (τ) of an RL circuit, which is the ratio of the inductance to the resistance ($\tau = L/R$), plays acrucial role in determining the transient response.

During the transient analysis of an RL circuit, the behavior depends on the initial conditions, the input voltage or current, the resistance, and the inductance. When a voltage or current is suddenly applied or removed from the RL circuit, the inductor reacts by generating a back EMF (electromotive force) that opposes the change in current. This results in a transient response characterized by an exponential rise or decay of the current.

$$i_L(t) = \frac{V_i}{R}(1 - e^{-\frac{t}{\tau}}) \rightarrow V_R(t) = V_i(1 - e^{-\frac{t}{\tau}}), \quad \text{Charging}$$

$$i_L(t) = \frac{V_i}{R}e^{-\frac{t}{\tau}} \rightarrow V_R(t) = V_i * e^{-\frac{t}{\tau}}, \quad \text{Discharging}$$

By conducting transient simulations, engineers can gain insights into the dynamic behavior of RL circuits, evaluate their performance, and make informed design decisions to ensure the desired functionality and stability of the circuit.

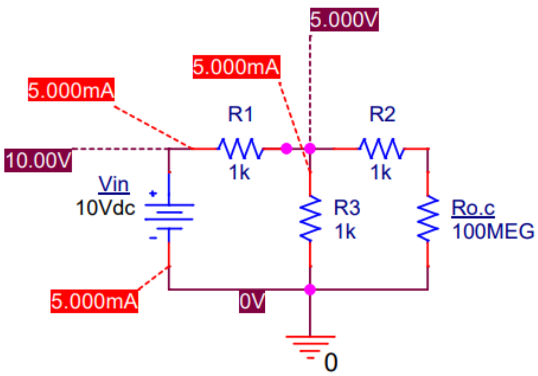
Calculating the time constant(τ):

	Charging	Discharging
Theoretical (τ)	$\tau = \frac{L}{R} = 3.9us$	$\tau = \frac{L}{R} = 3.9us$
Practical (τ)	when $V_R = 10 * (1 - e^{-1}) = 6.32V$ then $\tau = 4.1us$	when $V_R = 10 * (e^{-1}) = 3.67V$ then $\tau = 4.1us$
Error (τ)	$2us$	$2us$
Theoretical (5τ)	$5\tau = 5\frac{L}{R} = 19.5us$	$5\tau = 5\frac{L}{R} = 19.5us$
Practical (5τ)	when it be stable $5\tau = 21.1us$	when it be stable $5\tau = 21.1us$
Error (5τ)	$1.6us$	$1.6us$

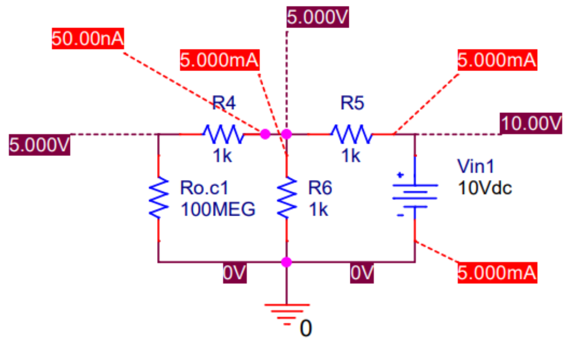
NOTE: we can notice that the output voltage attenuates by increasing the frequency of the input due to the LPF circuit as explained in the previous lab.

3 Lab-3: Two Port Network

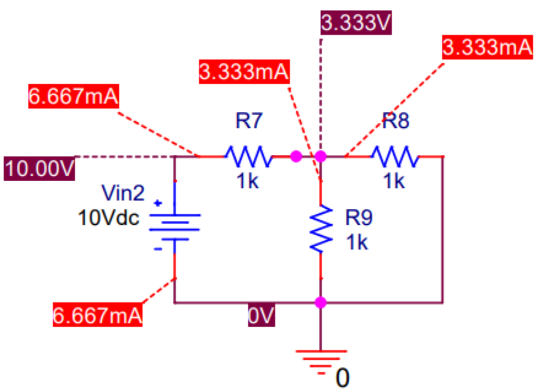
3.1 Calculating Z and Y from Two Port Network



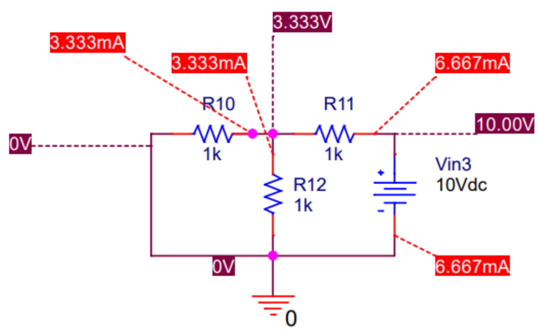
T Port Network for Z V_1 On



T Port Network for Z V_2 On



T Port Network for Y V_1 On



T Port Network for Y V_2 On

3.1.1 Discussion

$$Z_{11} = \frac{V_1}{I_1} = \frac{10V}{5mA} = 2k\Omega \tag{1}$$

$$Z_{22} = \frac{V_2}{I_2} = \frac{10V}{5mA} = 2k\Omega \tag{2}$$

$$Z_{21} = \frac{V_2}{I_1} = \frac{5V}{5mA} = 1k\Omega \tag{3}$$

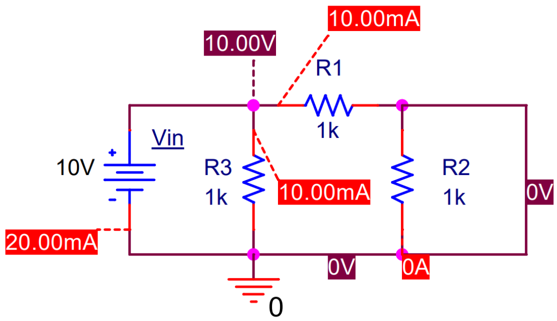
$$Z_{12} = \frac{V_1}{I_2} = \frac{5V}{5mA} = 1k\Omega \tag{4}$$

$$Y_{11} = \frac{I_1}{V_1} = \frac{\frac{20}{3}mA}{10V} = 0.667m\Omega^{-1} \tag{5}$$

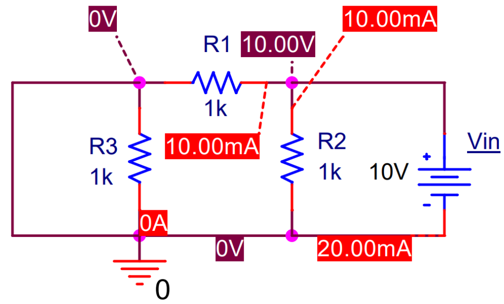
$$Y_{22} = \frac{I_2}{V_2} = \frac{\frac{20}{3}mA}{10V} = 0.667m\Omega^{-1} \tag{6}$$

$$Y_{21} = \frac{I_2}{V_1} = \frac{\frac{10}{3}mA}{10V} = 0.333m\Omega^{-1} \tag{7}$$

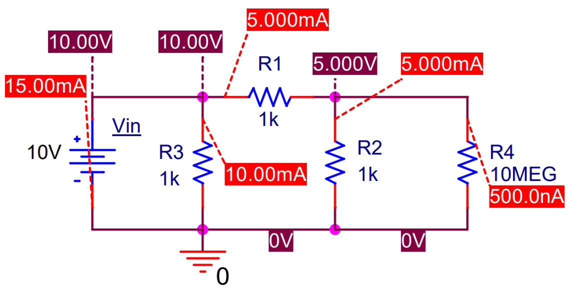
$$Y_{12} = \frac{I_1}{V_2} = \frac{\frac{10}{3}mA}{10V} = 0.333m\Omega^{-1} \tag{8}$$



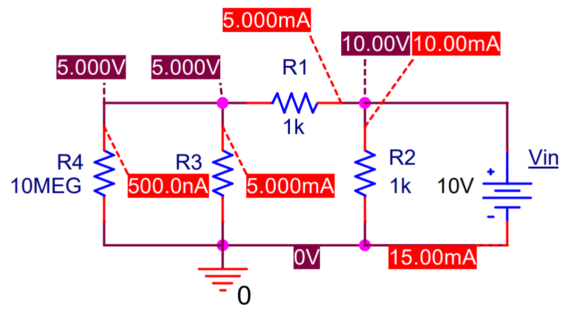
π Port Network for Z V_1 On



π Port Network for Z V_2 On



π Port Network for Y V_1 On



π Port Network for Y V_2 On

3.1.2 Discussion

$$Z_{11} = \frac{V_1}{I_1} = \frac{10V}{15mA} = \frac{2}{3}k\Omega \tag{9}$$

$$Z_{22} = \frac{V_2}{I_2} = \frac{10V}{15mA} = \frac{2}{3}k\Omega \tag{10}$$

$$Z_{21} = \frac{V_2}{I_1} = \frac{5V}{15mA} = \frac{1}{3}k\Omega \tag{11}$$

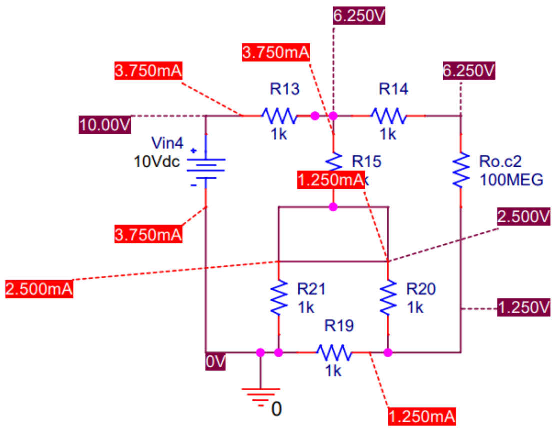
$$Z_{12} = \frac{V_1}{I_2} = \frac{5V}{15mA} = \frac{1}{3}k\Omega \tag{12}$$

$$Y_{11} = \frac{I_1}{V_1} = \frac{20mA}{10V} = 2m\Omega^{-1} \tag{13}$$

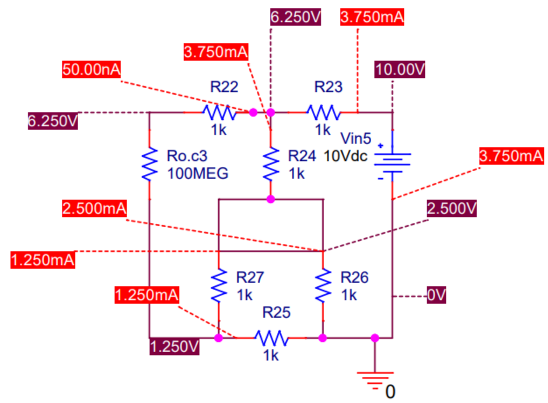
$$Y_{22} = \frac{I_2}{V_2} = \frac{20mA}{10V} = 2m\Omega^{-1} \tag{14}$$

$$Y_{21} = \frac{I_2}{V_1} = \frac{10mA}{10V} = 1m\Omega^{-1} \tag{15}$$

$$Y_{12} = \frac{I_1}{V_2} = \frac{10mA}{10V} = 1m\Omega^{-1} \tag{16}$$



Interconnection Port Network for Z V_1 On



Interconnection Port Network for Z V_2 On

3.1.3 Discussion

$$Z_{11} = \frac{V_1}{I_1} = \frac{10V}{3.750mA} = \frac{8}{3}k\Omega \tag{17}$$

$$Z_{22} = \frac{V_2}{I_2} = \frac{10V}{3.750mA} = \frac{8}{3}k\Omega \tag{18}$$

$$Z_{21} = \frac{V_2}{I_1} = \frac{(6.25-1.25)V}{3.75mA} = \frac{4}{3}k\Omega \tag{19}$$

$$Z_{12} = \frac{V_1}{I_2} = \frac{(6.25-1.25)V}{3.75mA} = \frac{4}{3}k\Omega \tag{20}$$

from the equations of the t and π we obtain

$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}_{\pi} + \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}_{t} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}_{\text{Interconnection}}$$