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1. **Aim of the experiment:** Familiarisation with Signal Generator, Oscilloscope, and studies on RC, CR, and RL circuits.

2. **Tools used:**

   Voltage Divider - Voltage signal generator, Capacitors, Resistors, Connecting wires, Oscilloscope, Multimeter.

   Frequency Response - Voltage signal generator, Capacitors, Resistors, Connecting wires, Oscilloscope, Inductor, Multimeter.

   Pulse Response - Square Wave Voltage Source, Rheostat, Capacitor, Inductor, Connecting Wires, Multimeter.

3. **Background knowledge (brief):**

   Voltage Divider - A simple circuit that can reduce voltage. It distributes the input voltage among the components of the circuit. The best example of a voltage divider is two resistors connected in series. The input voltage is applied across the resistor pair, and the output voltage is taken from a point between them. It produces different voltage levels from a common voltage source but with the same current for all components in the series circuit.

   Frequency Response -

Filters - They are primarily frequency selective circuits. There are different types of filters-Passive, Active, First Order, Second Order, etc. Passive filters consist of a combination of R, C, L.

Cut-off frequency - The frequency at which the amplitude decreases by 3 decibels.

For RC FIlters $fc = 1/2\pi RC$.

High Pass Filter - A high pass filter is an electronic filter that permits heightened signals than a particular cutoff frequency(fc). It attenuates signals with frequencies lower than that cutoff frequency. We measure the voltage across the resistance in RC high pass filter.

Low Pass Filter - A low pass filter is an electronic filter that permits signals lower than a specific cutoff frequency(fc). It attenuates signals with frequencies higher than that cutoff frequency. We measure the voltage across the capacitor in the RC low pass filter.

Pulse Response -

High Pass Filter(Differentiator) - A high-pass filter is a passive electronic filter that passes signals higher than a specific cutoff frequency(fc). It attenuates signals with frequencies lower than the cutoff frequency.

The input signal is applied across the capacitor, and output is taken across the resistor (in the case of the RC circuit).

Low Pass Filter(Integrator) - A low-pass filter is a passive filter that passes signals with a frequency lower than a selected cutoff frequency(fc) and attenuates signals with frequencies higher than the cutoff frequency.

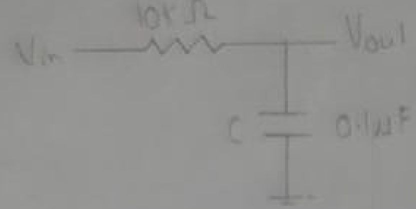
The input signal is applied across the resistor, and output is taken across the capacitor (in the case of the RC circuit).

4. Measurement Data (Tabular form):

Frequency Response -

Frequency Response :-

(a)

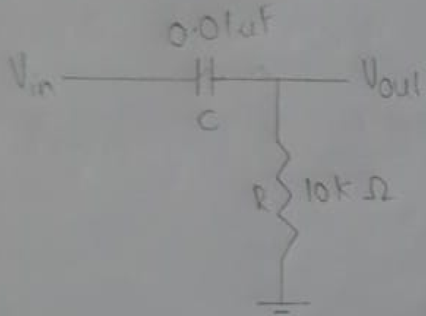


$R = 10{,}000\,\Omega$, $C = 0.1\times10^{-6}\,F$

Cutoff frequency $f_c = \dfrac{1}{2\pi RC} = \dfrac{1}{2\times\pi\times10{,}000\times0.1\times10^{-6}}$

$= 159.1549\,Hz$

(b)

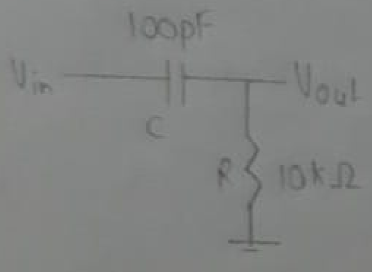


$R = 10{,}000\,\Omega$, $C = 0.01\times10^{-6}\,F$

Cutoff frequency $f_c = \dfrac{1}{2\pi RC} = \dfrac{1}{2\times\pi\times10000\times0.01\times10^{-6}}$

$= 1591.55\,Hz$

(c)

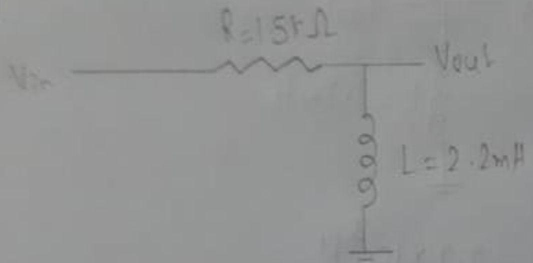


$R = 10{,}000\,\Omega$, $C = 100 \times 10^{-12}\,F$

$$\text{Cutoff frequency} = \frac{1}{2\pi RC} = \frac{1}{2 \times \pi \times 10{,}000 \times 100 \times 10^{-12}}$$

$$= 159.154\,kHz$$

(d)



$R = 1500\,\Omega$, $L = 2.2 \times 10^{-3}\,H$

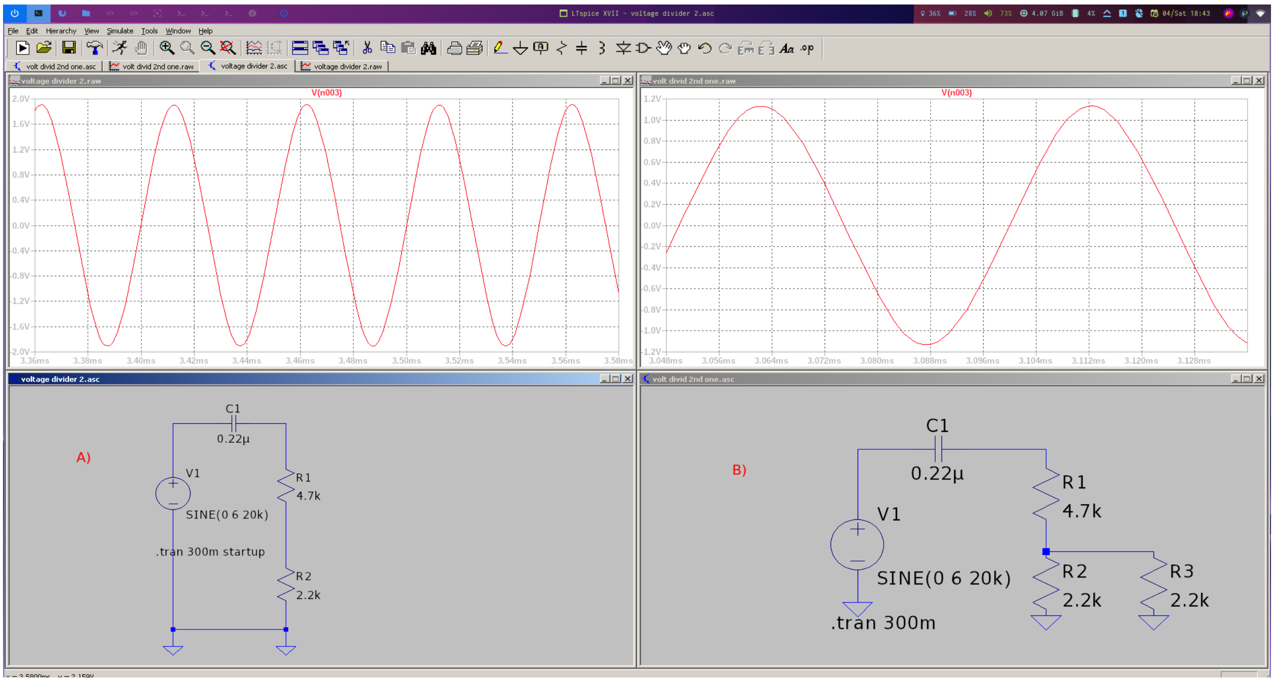
$$\text{Cutoff frequency } f_c = \frac{R}{2\pi L} = \frac{1500}{2 \times \pi \times 2.2 \times 10^{-3}}$$

$$= 108.514\,kHz.$$

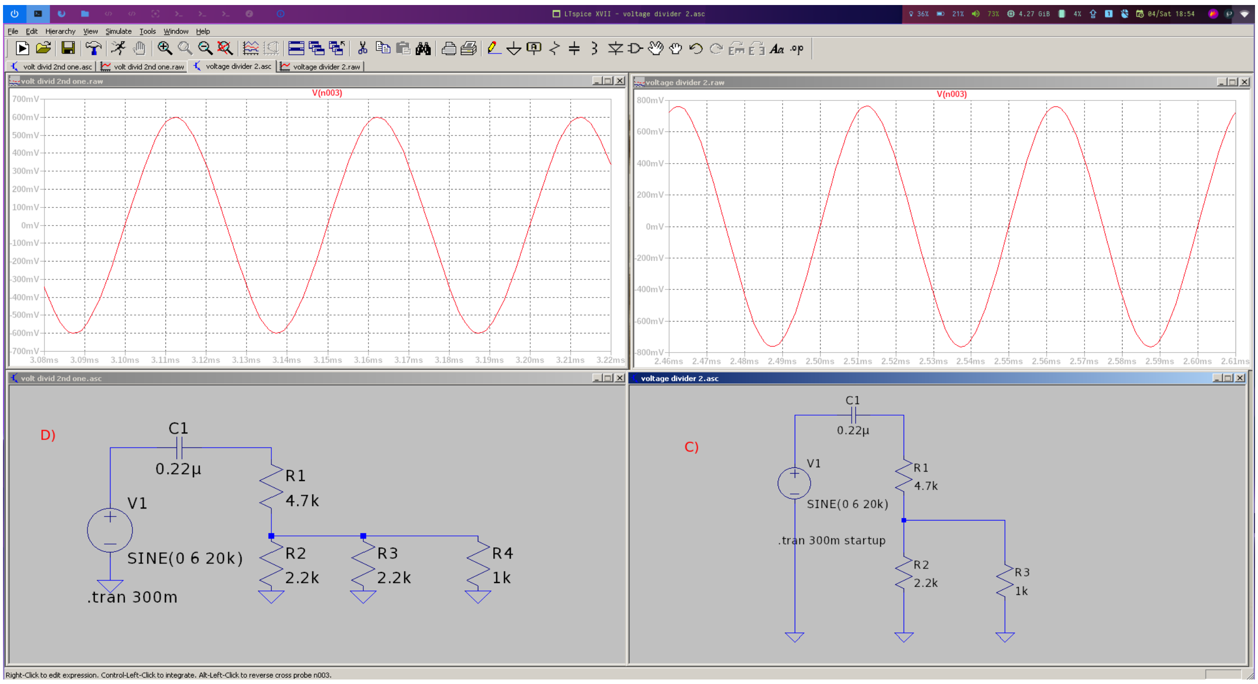
5. Graph (Image)/Screenshots:

Voltage Divider -

1)

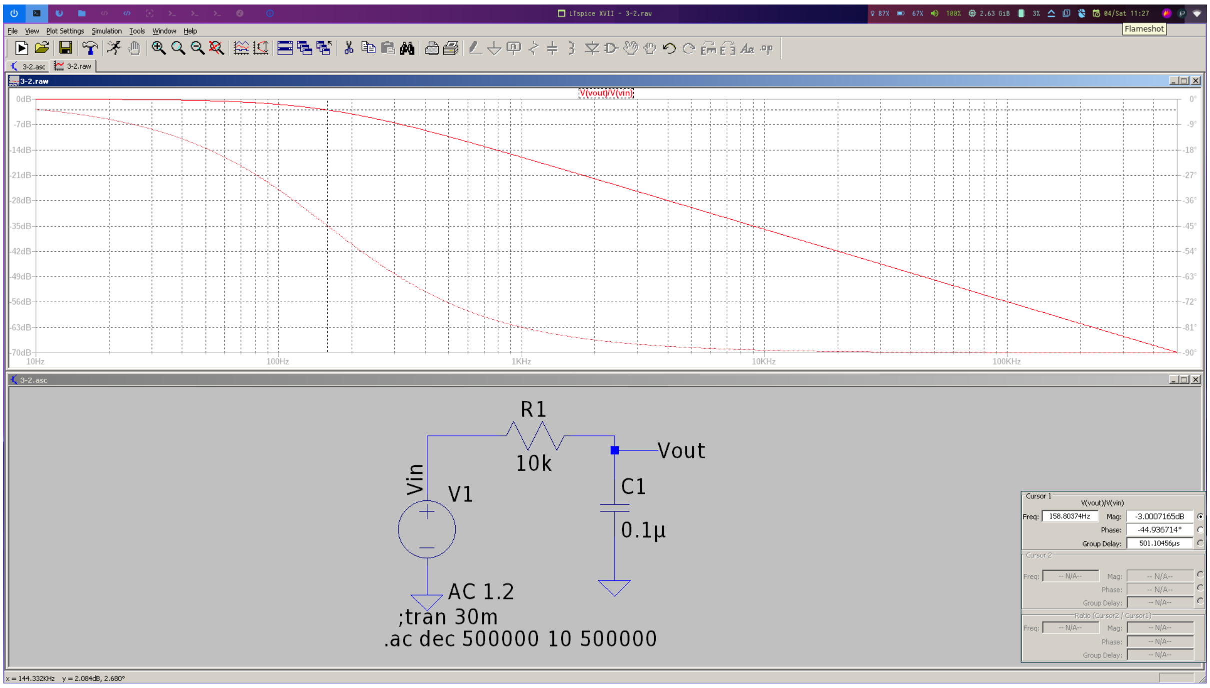


2)



Frequency Response -

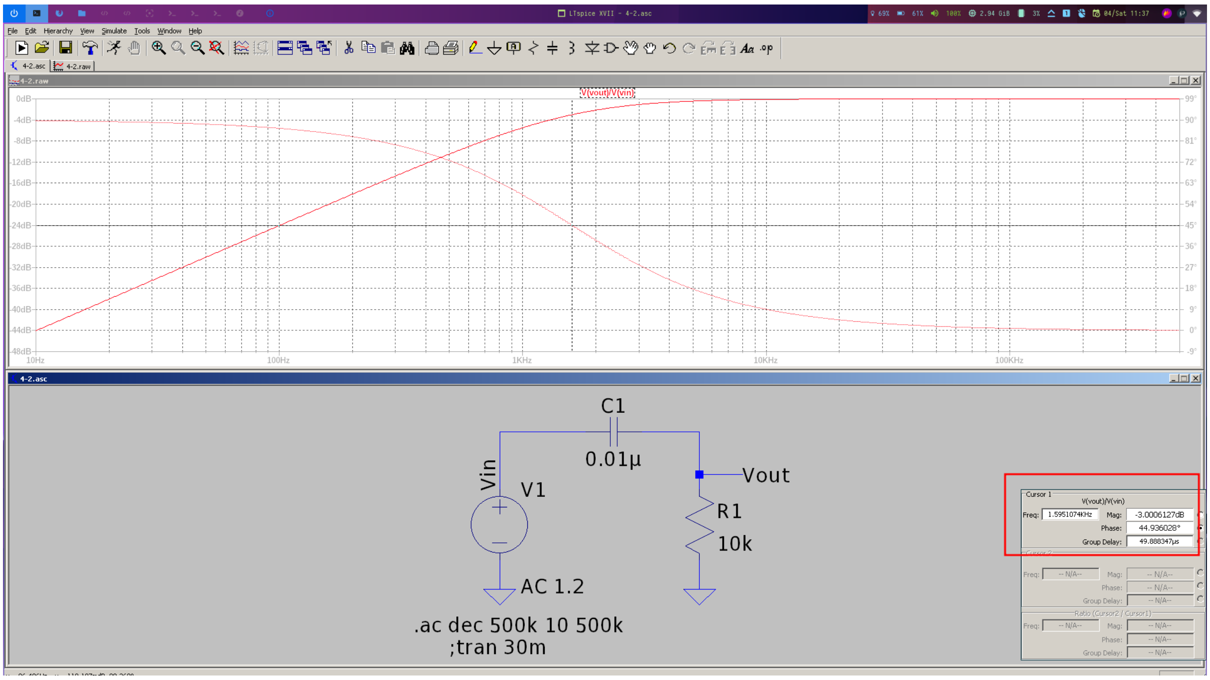
a) Low Pass Filter, R=10KΩ, C=0.1μF.



Cutoff Frequency from graph fc = 158.803Hz.

Theoretical Cutoff Frequency fc = 159.1549Hz.

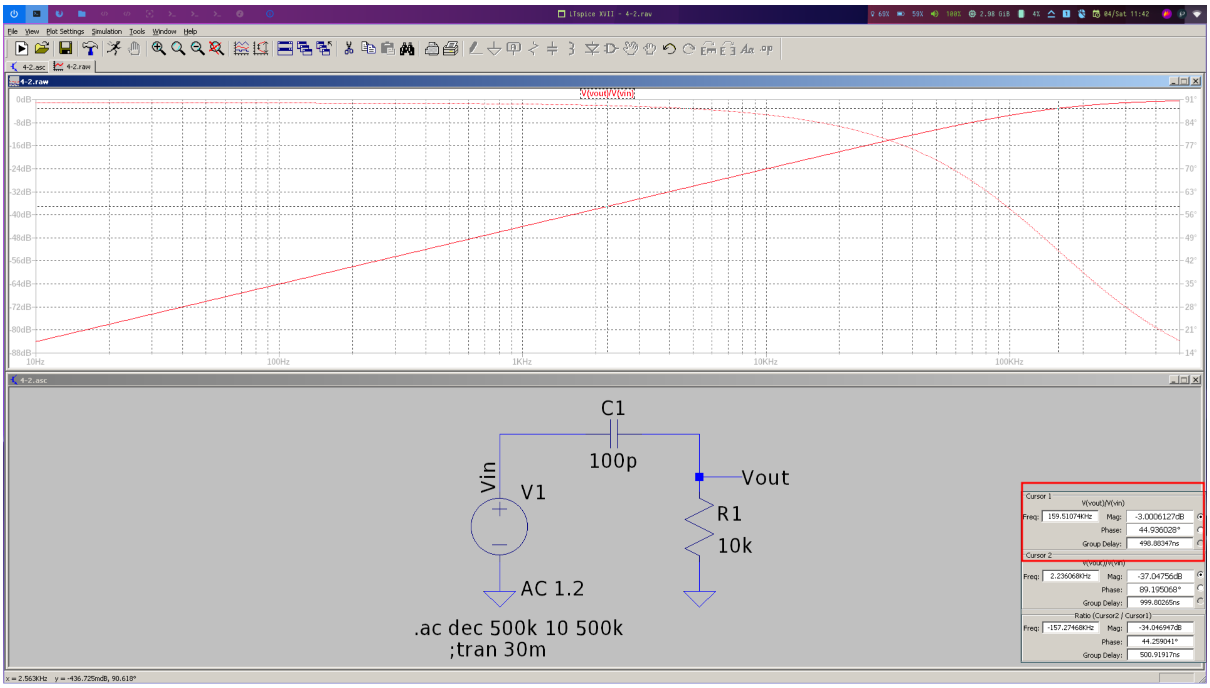
b) High Pass Filter, R=10KΩ, C=0.01μF.



Cutoff Frequency from graph fc = 1595.10Hz.

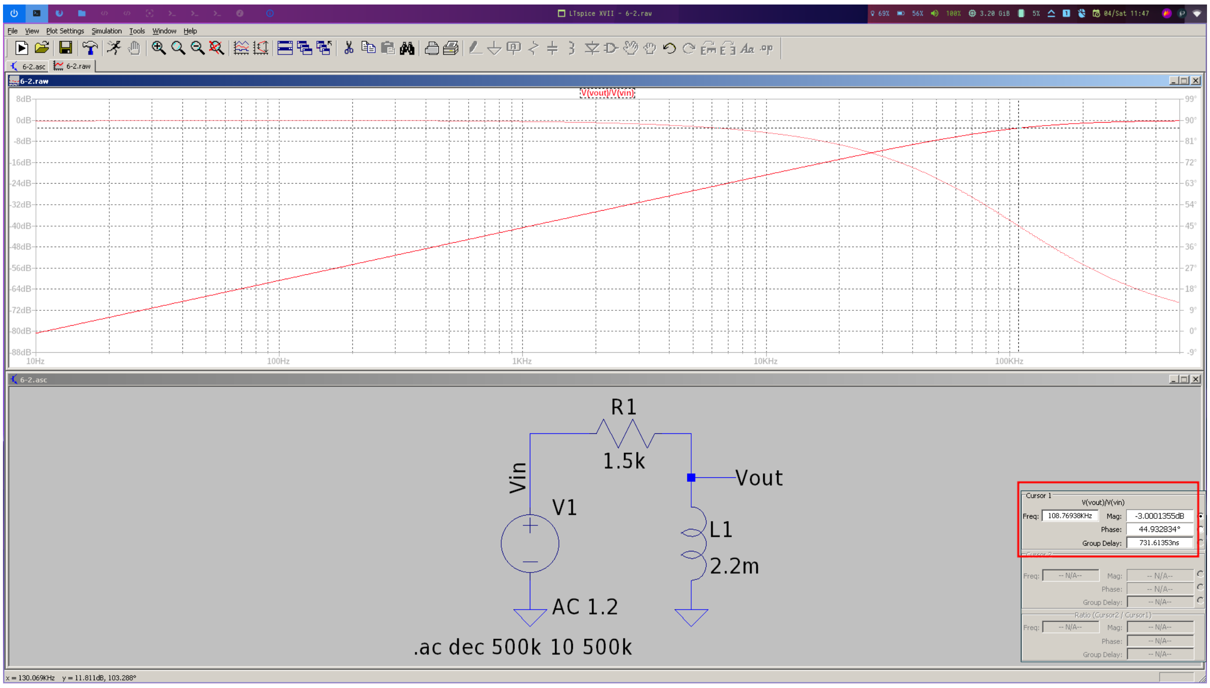
Theoretical Cutoff Frequency fc = 1591.55Hz.

c) High Pass Filter, R=10KΩ,C=100pF



Cutoff Frequency from graph fc = 159.510kHz.
Theoretical Cutoff Frequency fc = 159.154kHz.

d) High Pass Filter, R=1.5KΩ, L=2.2mH



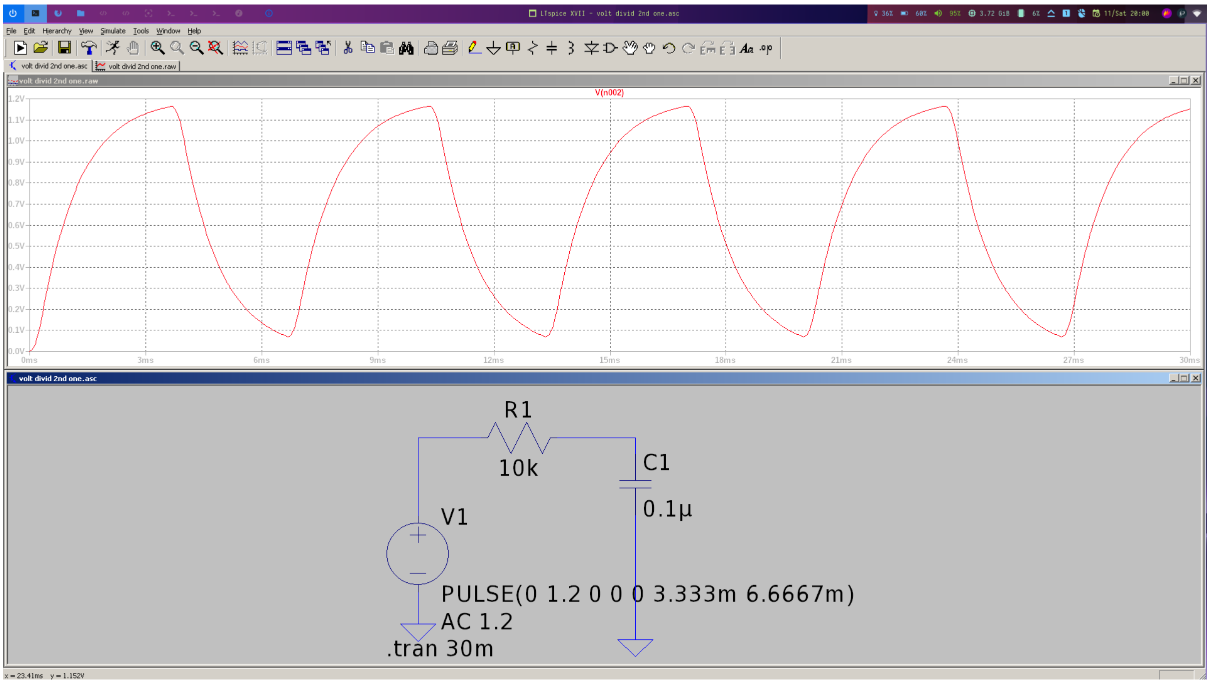
Cutoff Frequency from graph fc = 108.769kHz.

Theoretical Cutoff Frequency fc = 108.514kHz.

Pulse Response -

1) PRF = 150 Hz , R = 10KΩ , C = 0.1μF , Vin = 1.2V.

T >> RC (T = 1/PRF = 6.667ms)



Pulse response :-

For PRF = 150 Hz, R = 10 kΩ, C = 0.1 µf, $V_{in} = 1.2V$

$T >> RC \quad T = \frac{1}{PRF} = \frac{1}{150} = 6.6667\,ms.$

$\tau = 2.2RC = \frac{0.35}{f_c}$

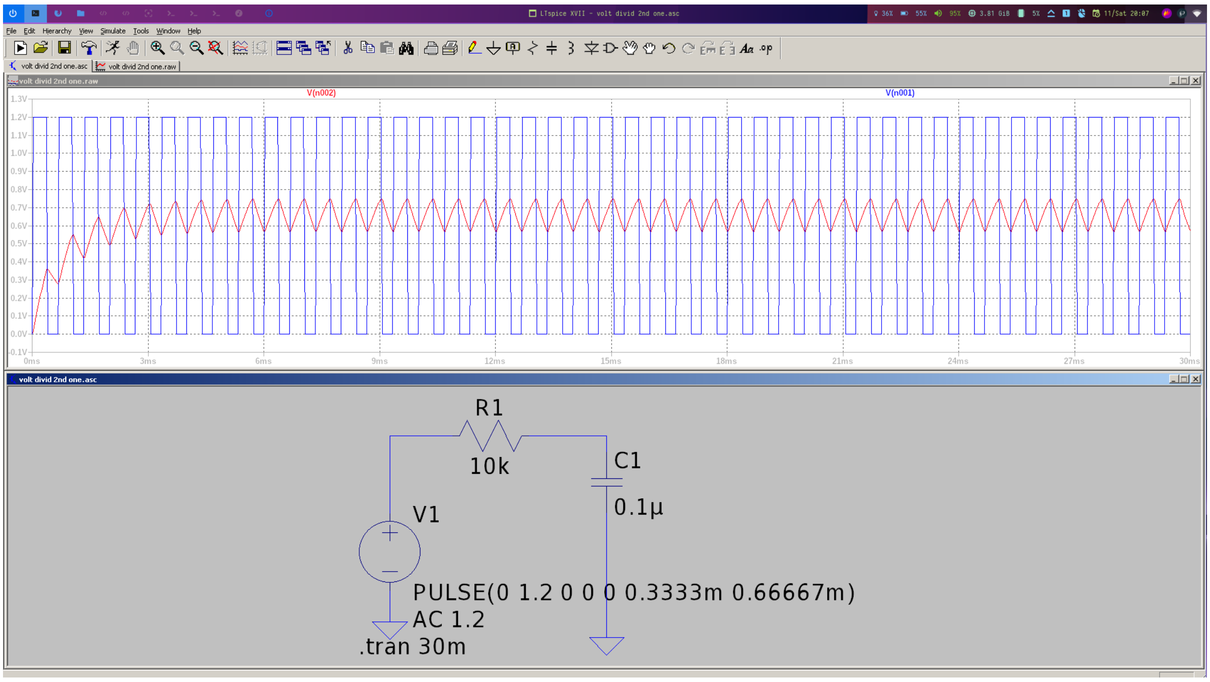
$f_c = \frac{0.35}{2.2 \times 10^{4} \times 10^{-7}} = 159.09\,Hz$

$f_c = 158.8\,Hz$ (From LTspice graph)

∴ The values are almost accurate but not exact

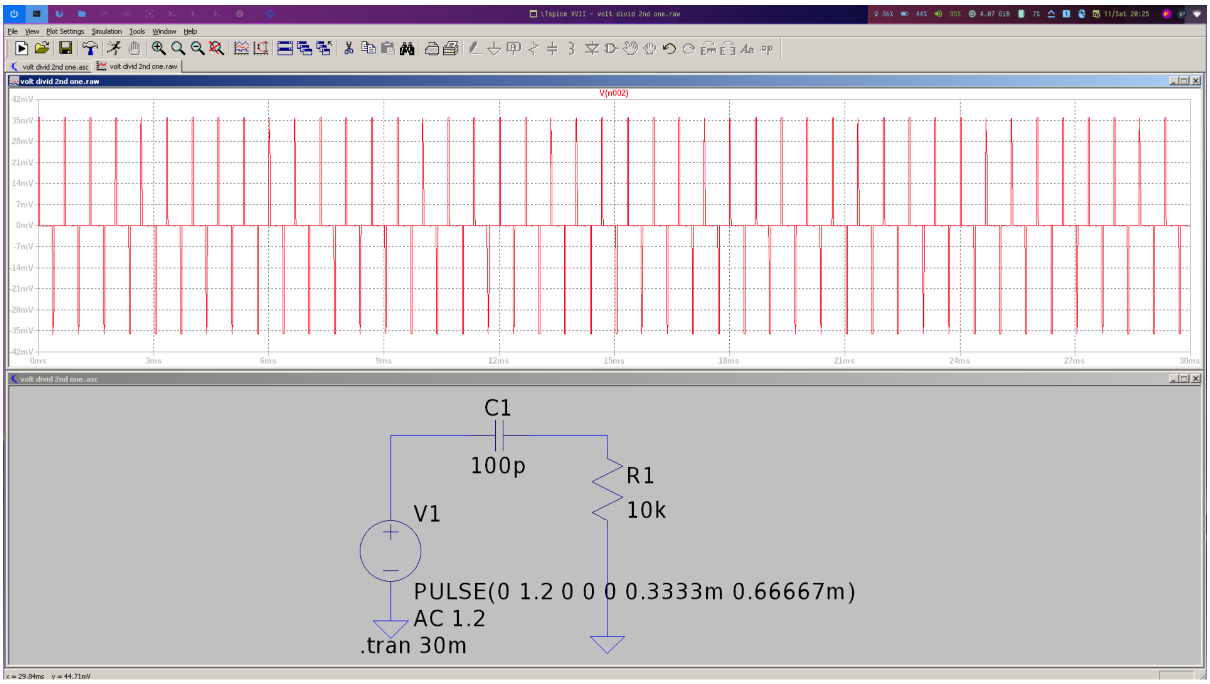
2) PRF = 1.5KHz , R = 10KΩ , C= 0.1μF , Vin = 1.2V.

T << RC (RC Integrator , T = 1/PRF = 0.6667ms)



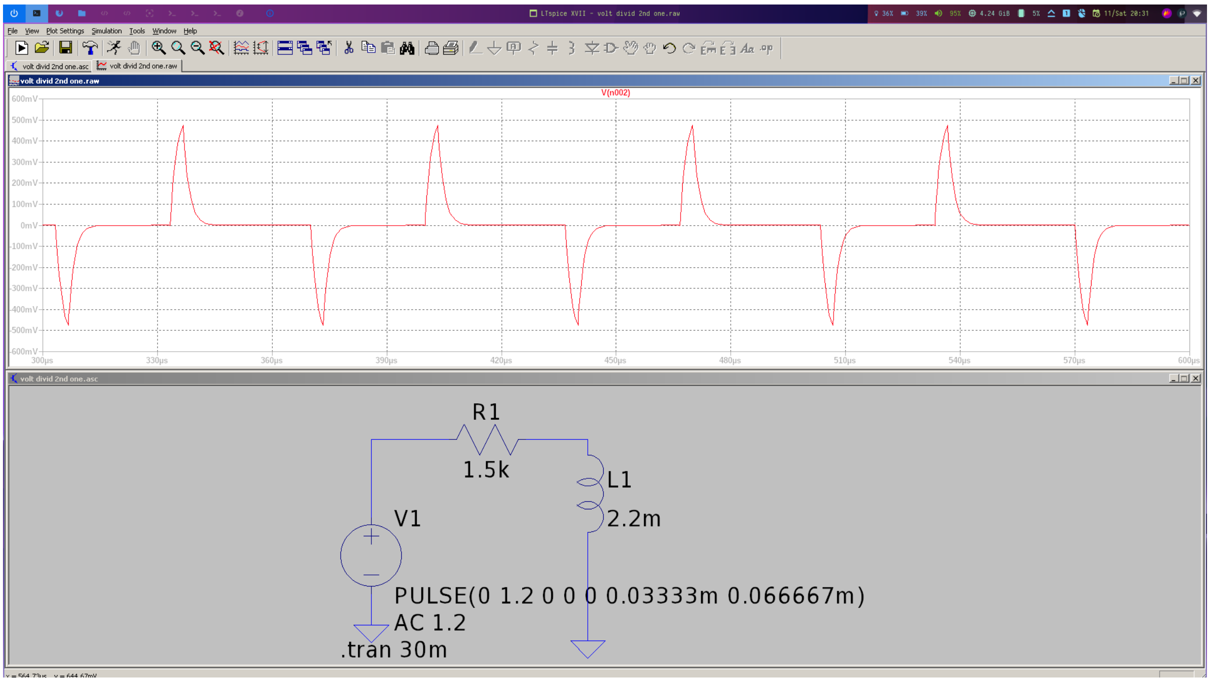
3)PRF = 1.5KHz , R = 10KΩ , C = 100pF , Vin = 1.2V.

T >> RC (RC Differentiator , T = 1/PRF = 0.667ms)



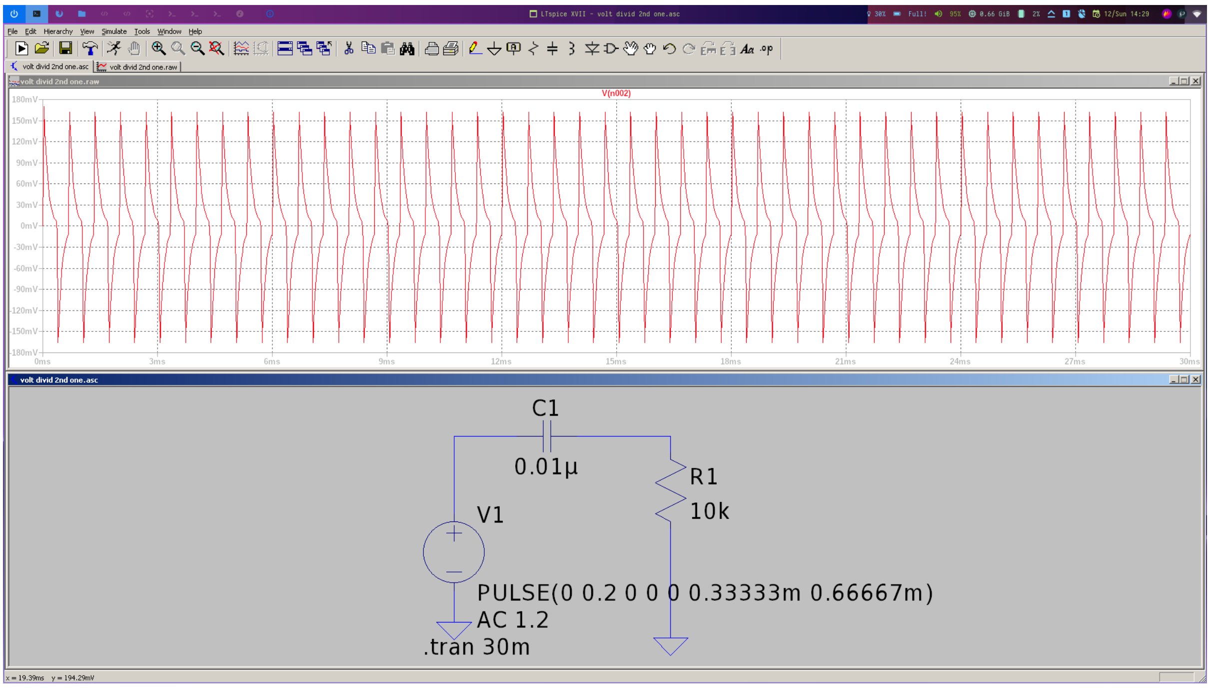
4) PRF = 15KHz , R = 1.5KΩ, L = 2.2mH , Vin = 1.2V.

T >> L/R (RL Differentiator , T = 1/PRF = 0.066667ms)



5)PRF = 1.5KHz , R = 10KΩ , C = 0.01μF , Vin = 1.2V.

T >> RC (RC Differentiator , T = 1/PRF = 0.667ms)



6. <u>Conclusion:</u>

Voltage Divider - Upon involving Sine wave and capacitors this time, we can observe for different conditions.

Frequency Response - We measure cutoff frequency at -3db in *20log(vout/vin)* *vs* *frequency decade* graph.CR.

Cutoff frequency $f_c = 1/2\pi RC$ (for RC/CR filters).

Cutoff frequency $f_c = R/2\pi L$ (for LR/RL filters).

The frequency response graphs show that theoretical cutoff frequencies and cutoff frequencies obtained from the graph are **almost accurate but not exact**.

Pulse Response - Long RC time constant will produce a triangular wave shape with low amplitude than the input signal as the capacitor has less time to charge or discharge fully. A short time constant allows the capacitor more time to charge and discharge, producing a more typical rounded shape.

7. <u>Discussions:</u>

Voltage Divider - Current and voltage in each part of the circuit are calculated similarly to series and parallel circuits using Kirchoff's laws.

Frequency Response - It is essential to understand the applications of filters. Nearly all electronic circuits consist of various filters. Filters are used in mic amplifiers, removing noise, etc...

Pulse Response - When the periodic time of the input waveform is shorter than(higher frequency) the circuits RC time constant, the output waveform resembles the input waveform, that is, a square wave. When the periodic time of the input waveform is much longer than (lower frequency) the circuits RC time constant, the output waveform is of narrow positive and negative spikes.