CENTRAL CONNECTICUT STATE UNIVERSTY

SCOOL OF ENGINEERING,

SCIENCE, AND TECHNOLOGY

1615 Stanley St., New Britain,

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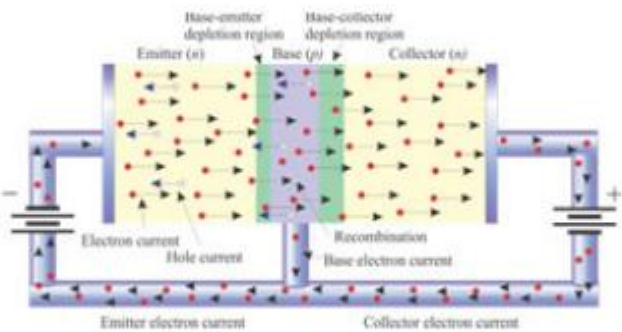
Chapter 15_ ACTIVE FILTERS

LAB_10

Circuit_passive_ Low Pass, Hgh Pass, Band Pass and Band Stop



To **: Professor . Dr. Park Sangho**

Computer engineering Technology

From**: Van Thi Minh Nguyen**

CET 323_01 CRN: 11342

November 28th , 2020

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CET 323 LAB

Dr. Park

Date November 28th , 2020.

Class CET 323_01

Name Van Nguyen

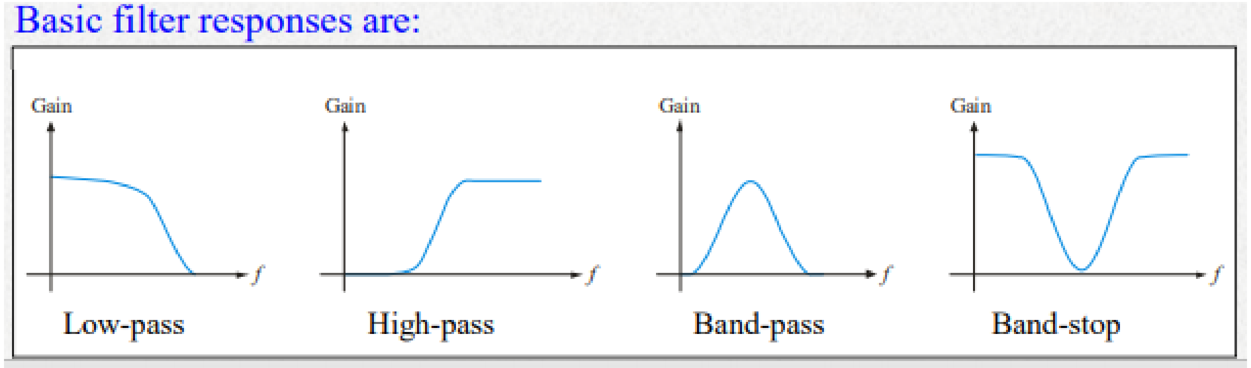
LAB_10

PASSIVE FILTERS (SIMULATION)

Reading

Floyd, Electronic Devices, Ninth Edition, **Chapter 15. Active Filters**

- Passive filters include passive components only: resistors (R), inductors (L), and capacitors (C). Low-pass, High-pass, Band-pass, and Band-stop filters will be tested

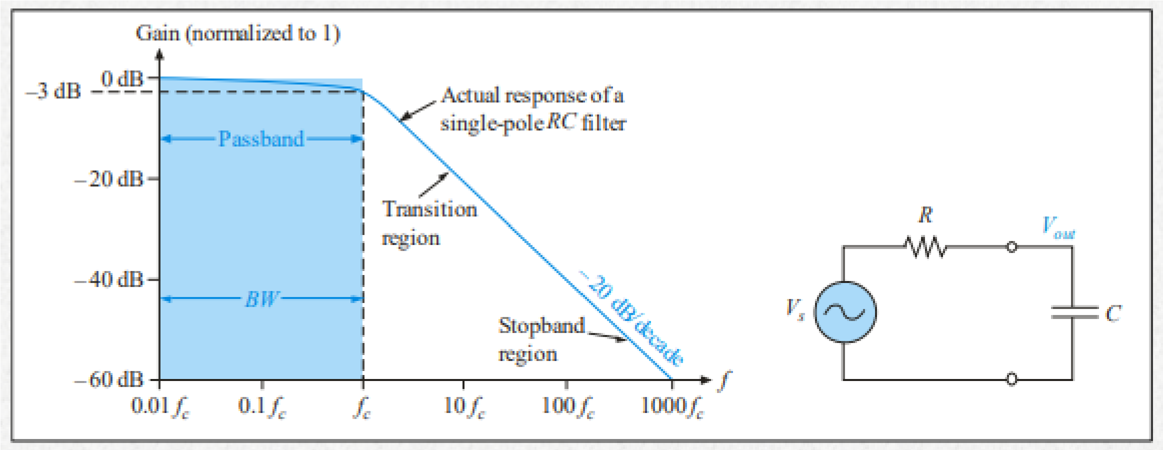


Part 1 : Circuit Passive LOW-Pass .

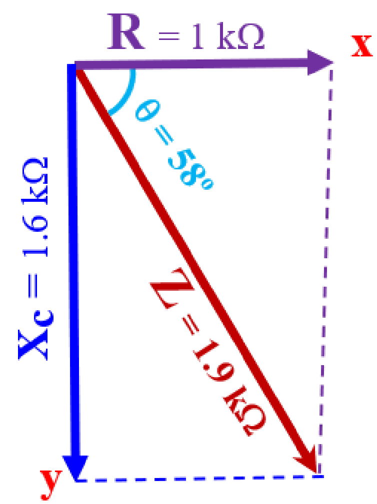
- For a given frequency, a series Rc circuit can be used to produce a phase lag by a specific amount between an input voltage and an output (the capacitor) that passes low frequencies and rejects all others.

Implement and simulate passive filters by using RC or RLC circuits with:

- Vs = 1Vp sine wave of frequency 100 Hz and phase 0 degrees.
- R = 1 kΩ
- L = 1 mH
- C = 1 µF



1)- Calculate the Generalized Impedances of the circuit.



- In a series RC circuit the Total impedance is phasor Sum of **R** and **-jXc.**
  - Phasor represented as vectors on the x, y coordinate plane in it

    R is positive X-axis

    Xc is Negative y-axis

    ⇨ **Z** is the rectangle's diagonal

- Applying Capacitive reactance formula we have :

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\,(3.1416)(100\ \text{Hz})(1\ \mu\text{F})} \approx 1.6 \times 10^{-6}\text{M}\Omega = \mathbf{1.6\ k\Omega}$$

- Applying Pythagoras theorem we have:

$$Z^2 = X_C^2 + R^2 \quad => \quad Z = \sqrt{X_C^2 + R^2} = \sqrt{1.6\ \text{k}\Omega^2 + 1\ \text{k}\Omega^2} \approx 1.9\ \text{k}\Omega \quad =>$$

$$\boxed{Z = 1.9\ \text{k}\Omega}$$

- Using formula, Inverse Trigonometric Functions in Right Triangles. We have:

$$\theta = \tan^{-1}\left(\frac{X_C}{R}\right) = \tan^{-1}\left(\frac{1.6\ \text{k}\Omega}{1\ \text{k}\Omega}\right) \approx 58°$$

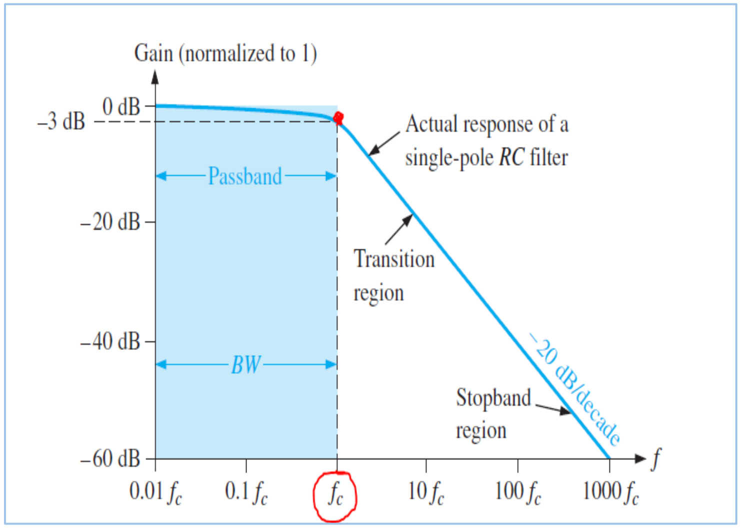
2) Calculate critical frequency (*cutoff frequency*) .

- The critical frequency, (also called the cutoff frequency) defines the end of the passband and is normally specified at the point where the response drops -3 dB (70.7%)

- The critical frequency of a low-pass RC filter occurs when Xc = R. where

  - The critical frequency is determined by the values of the resistors and capacitors in RC circuit

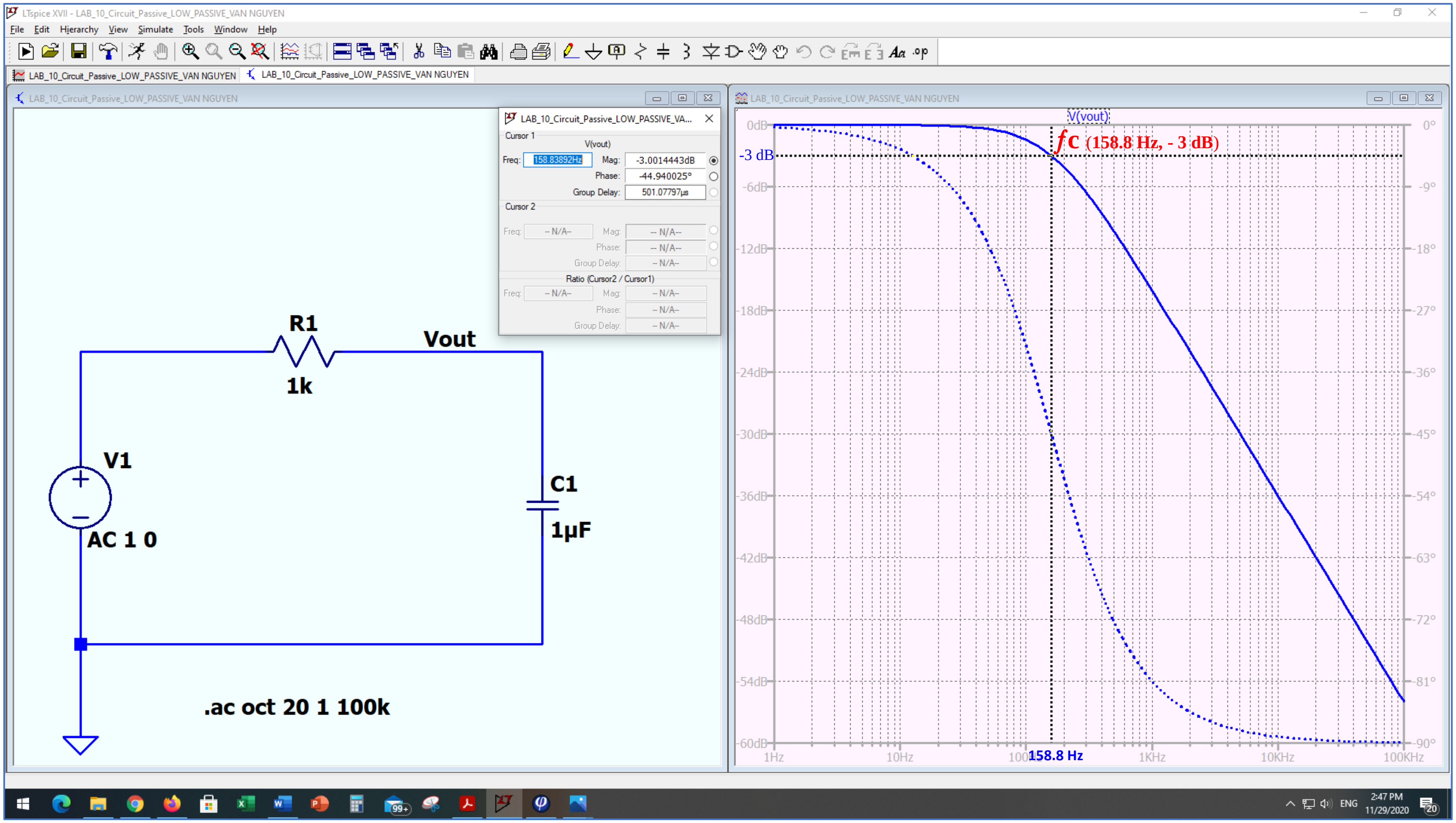
  with formula



$$f_C = \frac{1}{2\pi RC} = \frac{1}{2(3.1416)(1\ k\Omega)(1\ \mu F)} = 159\ \text{Hz}$$

$$\boxed{f_C = 159\ \text{Hz}}$$

3) Measure critical frequency (*cutoff frequency*) **fc = 158.8 Hz**



4) Calculate the phase of the output voltage compared to the input voltage.

- Ohm's law is applied to series RC circuits using phasor quantities of Z, V, and I. so we have formula

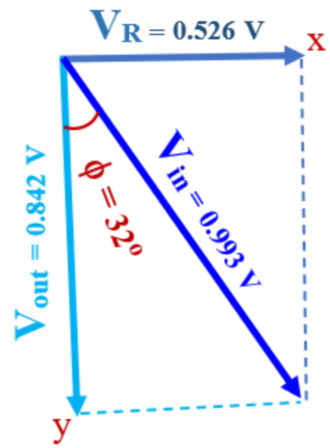
$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{Z}} = \frac{\mathbf{1\ V}}{\mathbf{1.9\ k\Omega}} = 0.526\ 3\ \text{mA} \quad => \quad \boxed{\mathbf{I = 0.526\ 3\ mA}}$$

- For a given frequency, a series RC circuit can be used to produce a phase lag by a specific amount between an input voltage and an output by taking the output across the capacitor.

$$V_{out} = V_C = I \times X_C = 0.526\ 3\ \text{mA} \times 1.6\ \text{k}\Omega = 0.842\ \text{V}$$

$$V_R = I \times R = 0.526\ 3\ \text{mA} \times 1\ \text{k}\Omega = 0.526\ \text{V}$$

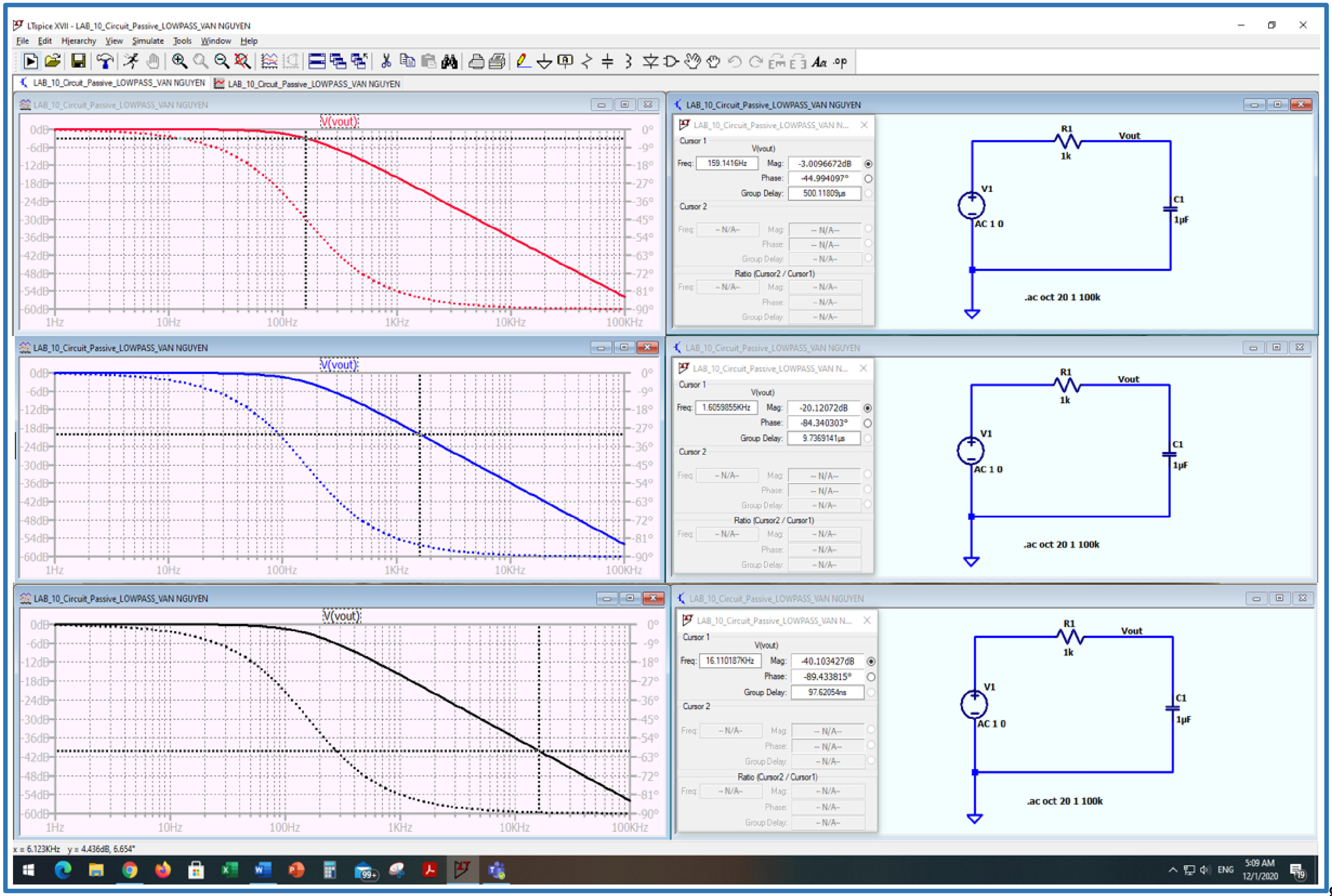
$$V_{in}^2 = V_C^2 + V_R^2 \;=>\; V_{in} = \sqrt{V_C^2 + V_R^2} = \sqrt{0.842\ \text{V}^2 + 0.526\ \text{V}^2} \approx \mathbf{0.993\ V}$$



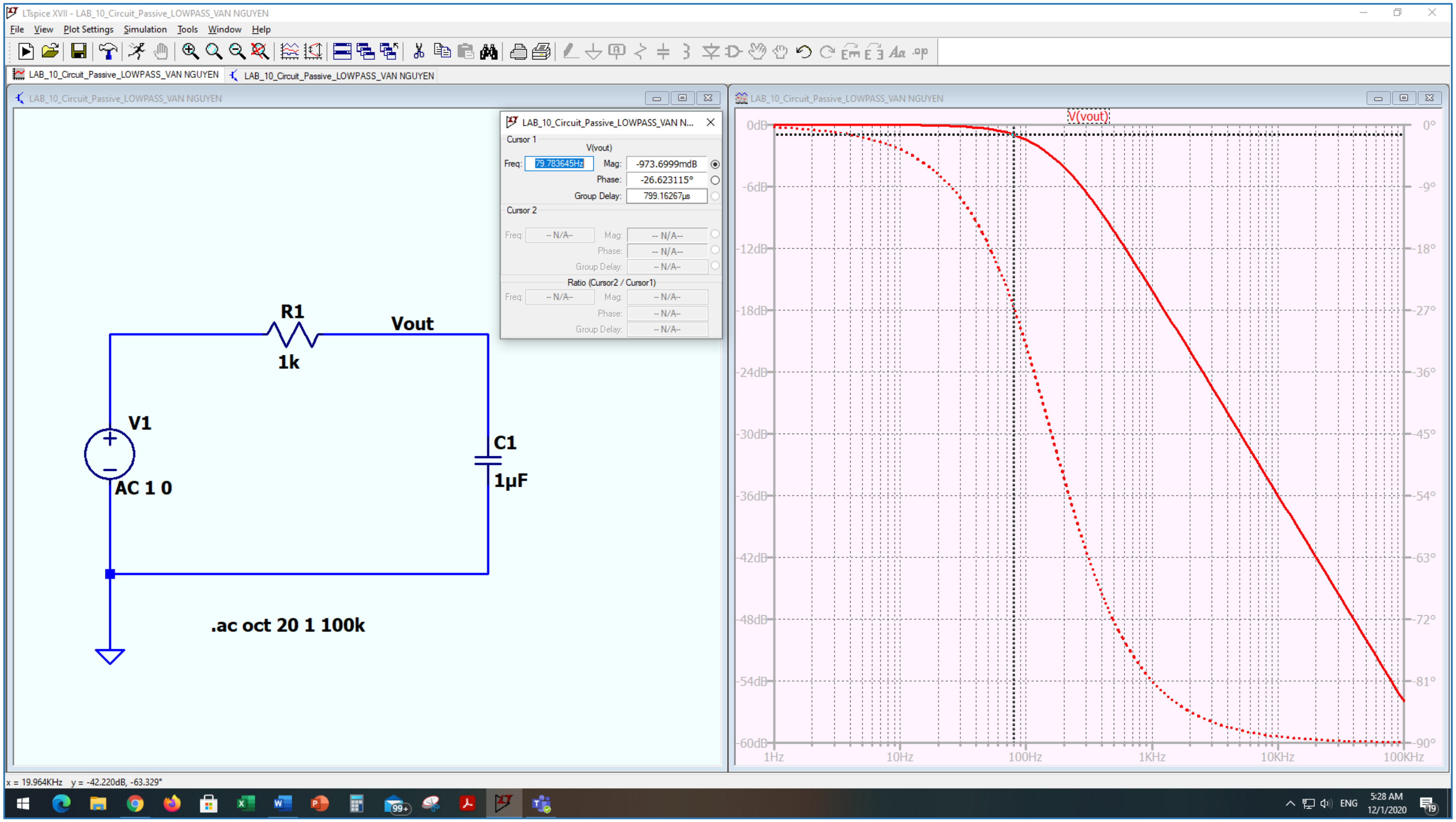
$$\phi = \tan^{-1}\left(\frac{V_R}{V_C}\right) = \tan^{-1}\left(\frac{0.526\ \text{V}}{0.842\ \text{V}}\right) \approx \mathbf{32°}$$

$$\boxed{\phi = 32^{o}}$$

5)-**Measure the phase shift amount at the critical frequency**_*Variation of phase angle with frequency.*(-3db, -20dB, -40db)



6)- **Test the circuit to get half f_c value.** fc = 79.7 Hz

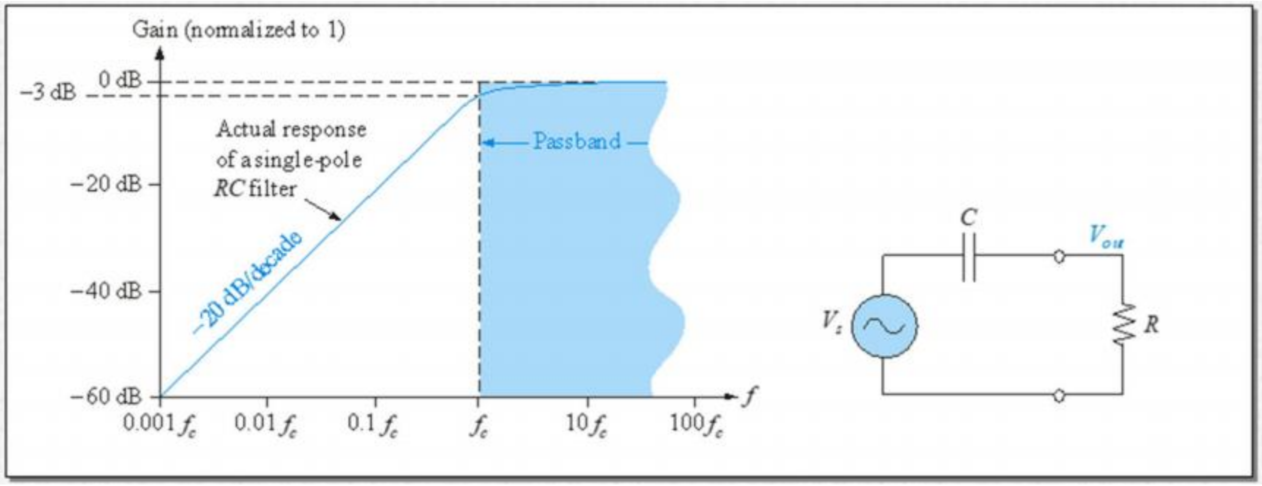


Part 2 : Circuit Passive HIGH -Pass

- Reversing the components in the previous circuit produces a circuit that is a basic lead network. a circuit that passes high frequencies and rejects all others.V$_{out}$ through resistor (**R**)

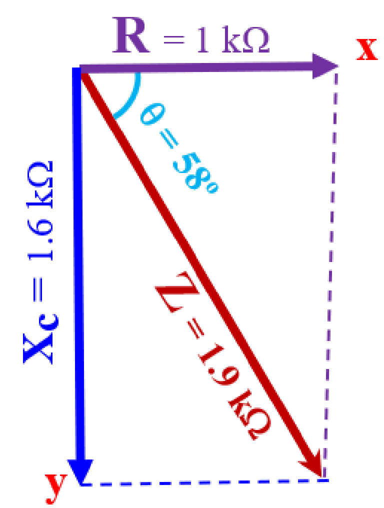
You will implement and simulate passive filters by using RC or RLC circuits with:

- Vs = 1Vp sine wave of frequency 100 Hz and phase 0 degrees.
- R = 1 kΩ
- L = 1 mH
- C = 1 μF



1) - Calculate the Generalized Impedances of the circuit

The Generalized Impedances of the circuit the same Part 1 of Low-pass filter, Because the values of R, L, C, V and fc, are not change, So Generalized Impedances of this circuit **Z = 1.9 kΩ**



$$\boxed{Z = 1.9\ k\Omega}$$

2)- Calculate critical frequency.

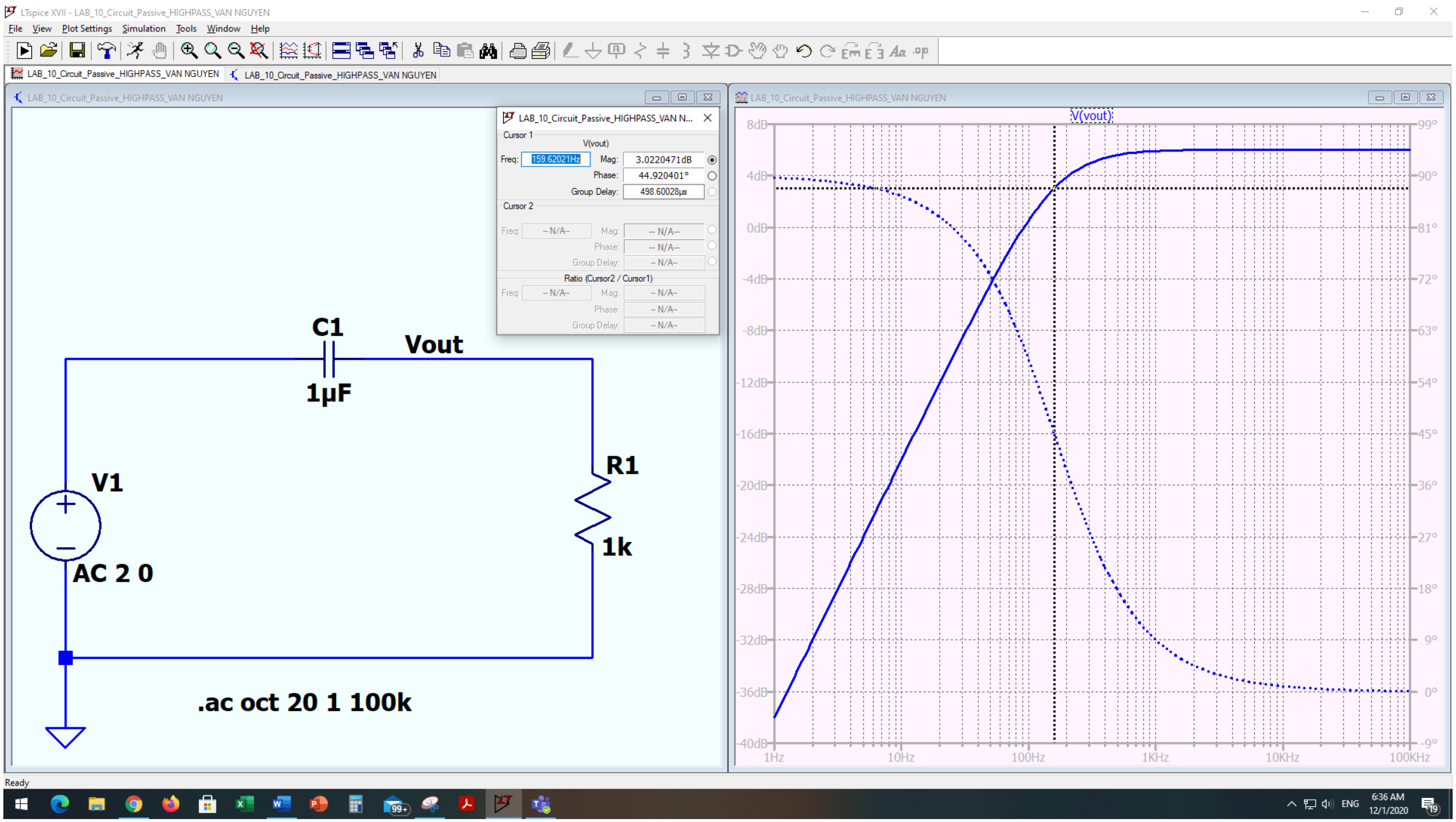
$$\boxed{f_C = \frac{1}{2\pi RC}}$$

The critical frequency of the circuit the same Part 1 of Low-pass filter, Because the values of R, L, C, and V are not change

So The critical frequency **fc = 159 Hz**

$$\boxed{f_C = 159\ \text{Hz}}$$

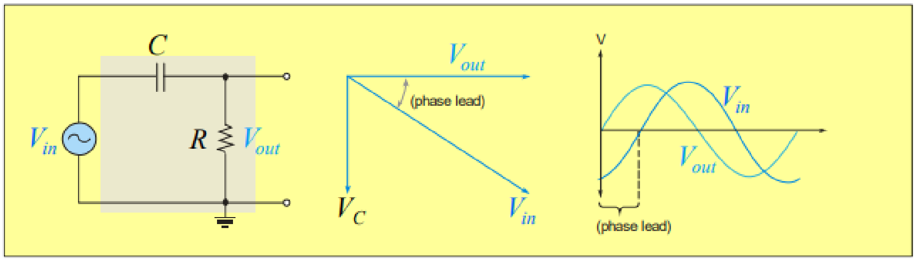
3) Measure critical frequency *fc* = 159Hz (– 3 dB)



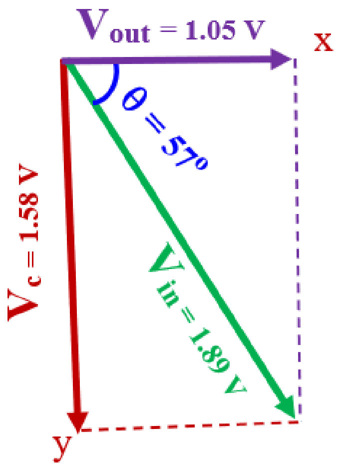
4) - Calculate the phase of the output voltage compared to the input voltage.

- Ohm's law is applied to series RC circuits using phasor quantities of Z, V, and I. so we have formula

$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{Z}} = \frac{\mathbf{2\ V}}{\mathbf{1.9\ k\Omega}} = 1.05\ \text{mA}$$



- V_{out} = (1.05 mA)(1 kΩ) = **1.05 V**
- V_c = (1.05 mA)(1.6 kΩ) = 1.58 V

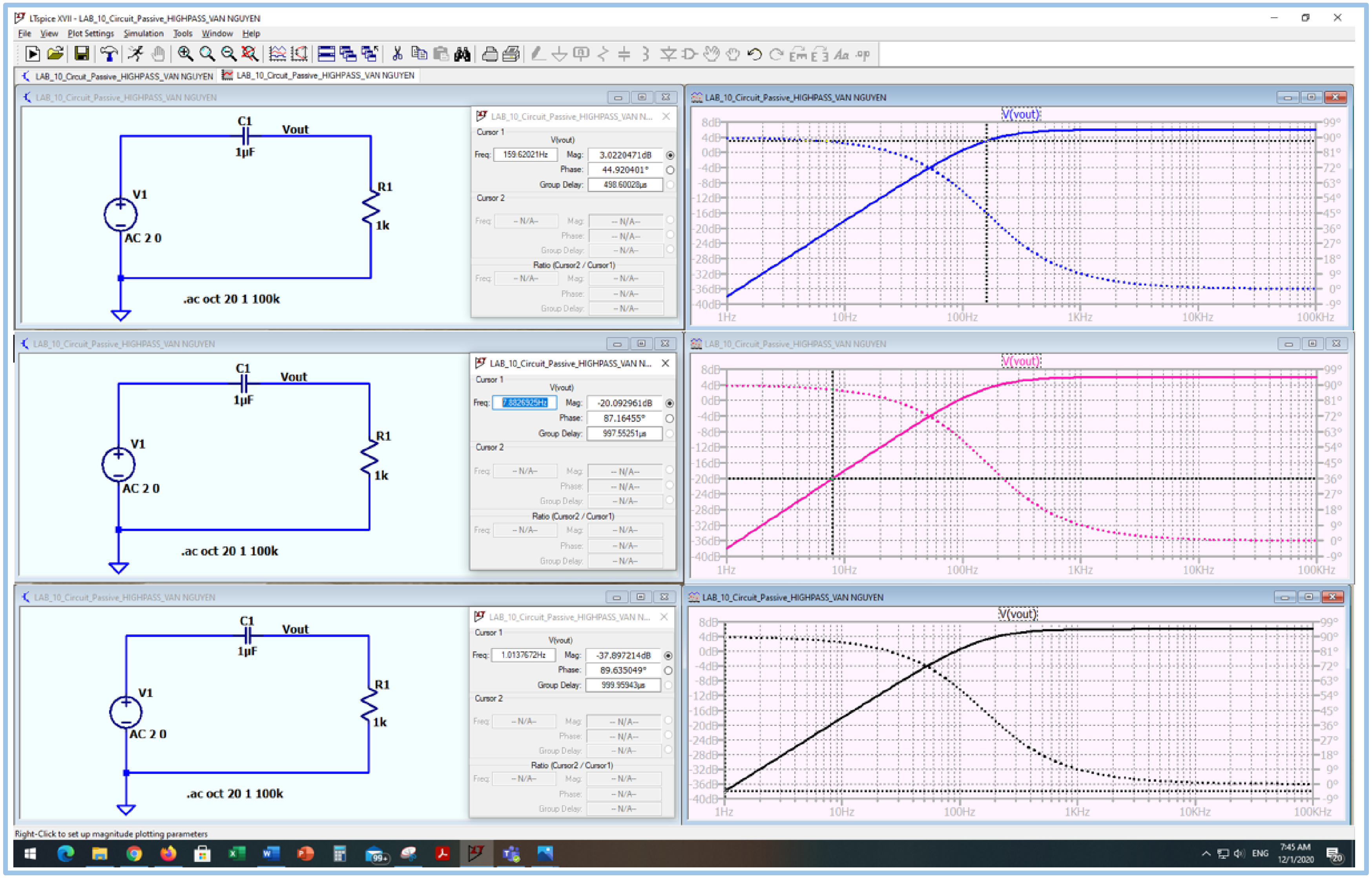


- $\mathbf{V_{in}} = \sqrt{1.05\ \text{V}^2 + 1.58\ \text{V}^2} = 1.89\ \text{V}$

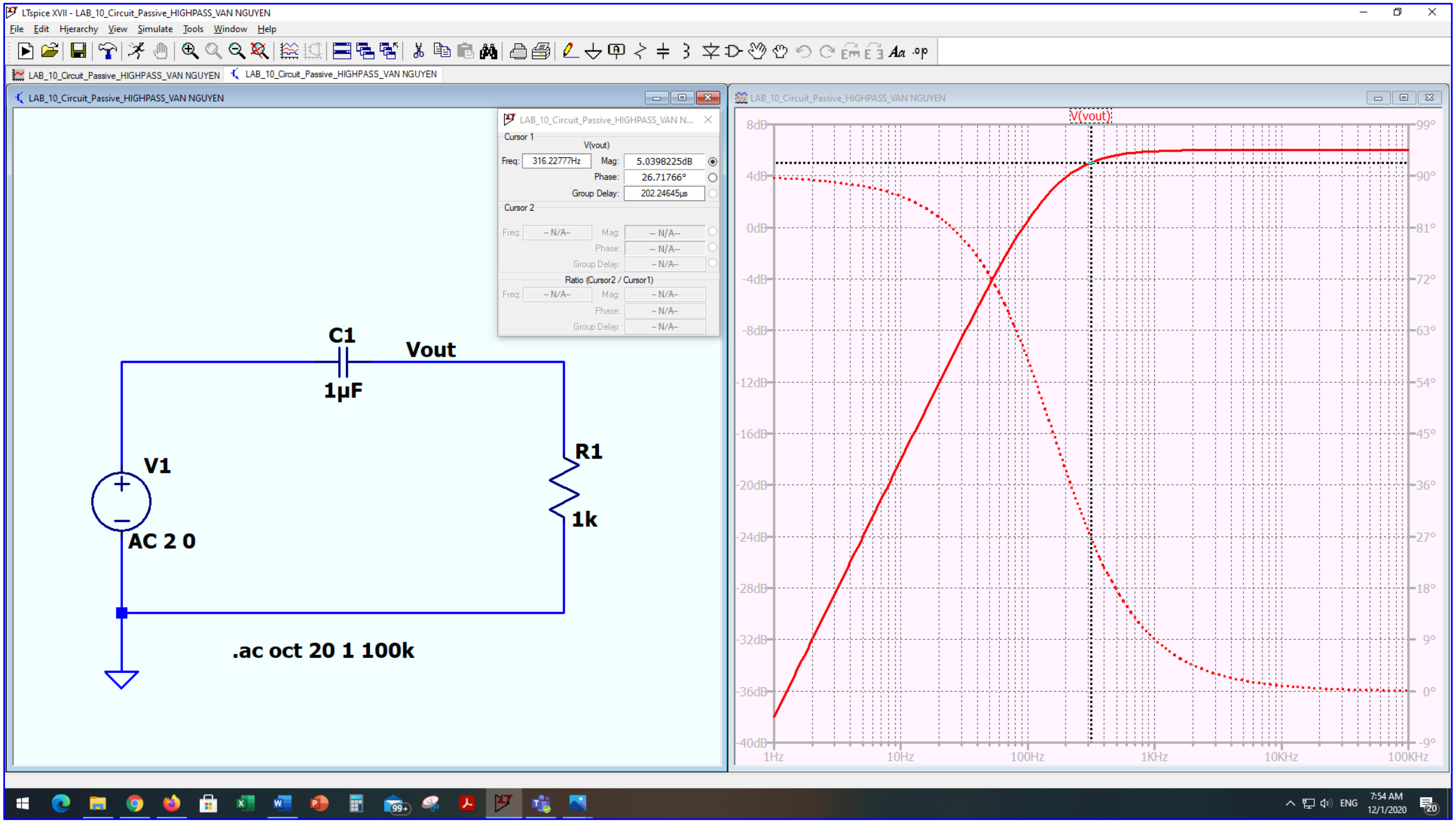
$$\theta = \tan^{-1}\left(\frac{\mathbf{V_C}}{\mathbf{V_{out}}}\right) = \tan^{-1}\left(\frac{\mathbf{1.58\ V}}{\mathbf{1.05\ V}}\right) \approx \mathbf{57^\circ}$$

$$\boxed{\theta = 57^\circ}$$

5)- Measure the phase shift amount at the critical frequency.(3dB, - 20dB, -37.8 dB)



6)- Adjust and test the circuit to get twice *f*c value. *f*c = 316 Hz (5 dB)

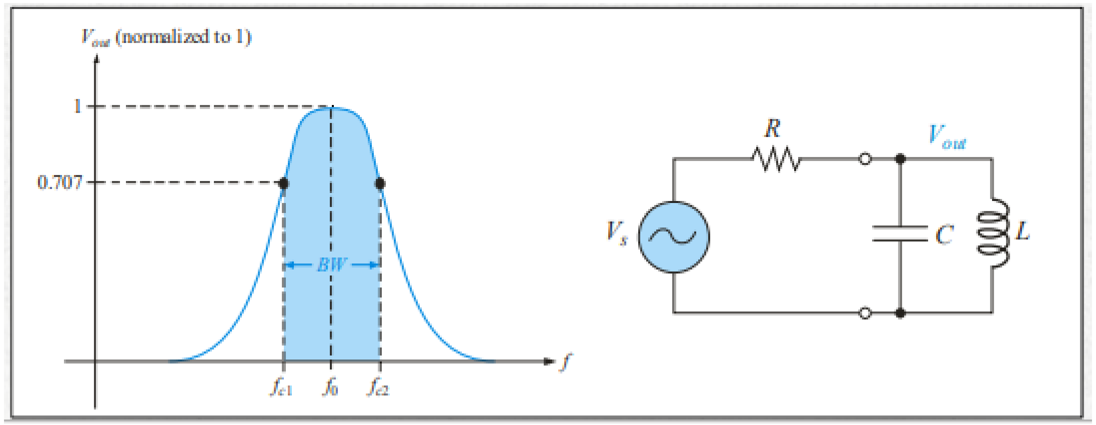


Part 3 : The Band-PASS Filter

- A band-pass filter passes all frequencies between two critical frequencies. The bandwidth is defined as the difference between the two critical frequencies. The simplest band-pass filter is an RLC circuit.

Implement and simulate passive filters by using RC or RLC circuits with:

- Vs = 1Vp sine wave of frequency 100 Hz and phase 0 degrees.
- R = 1 kΩ
- L = 1 mH
- C = 1 µF



1)- Calculate the center frequency f_0.

- We have formula : $f_0 = \sqrt{f_{C1} f_{C2}}$

- The lower frequency f_{C1} of the passband is the critical frequency of the HIGH-pass filter.
- The upper frequency f_{C2} is the critical frequency of the LOW-pass filter.

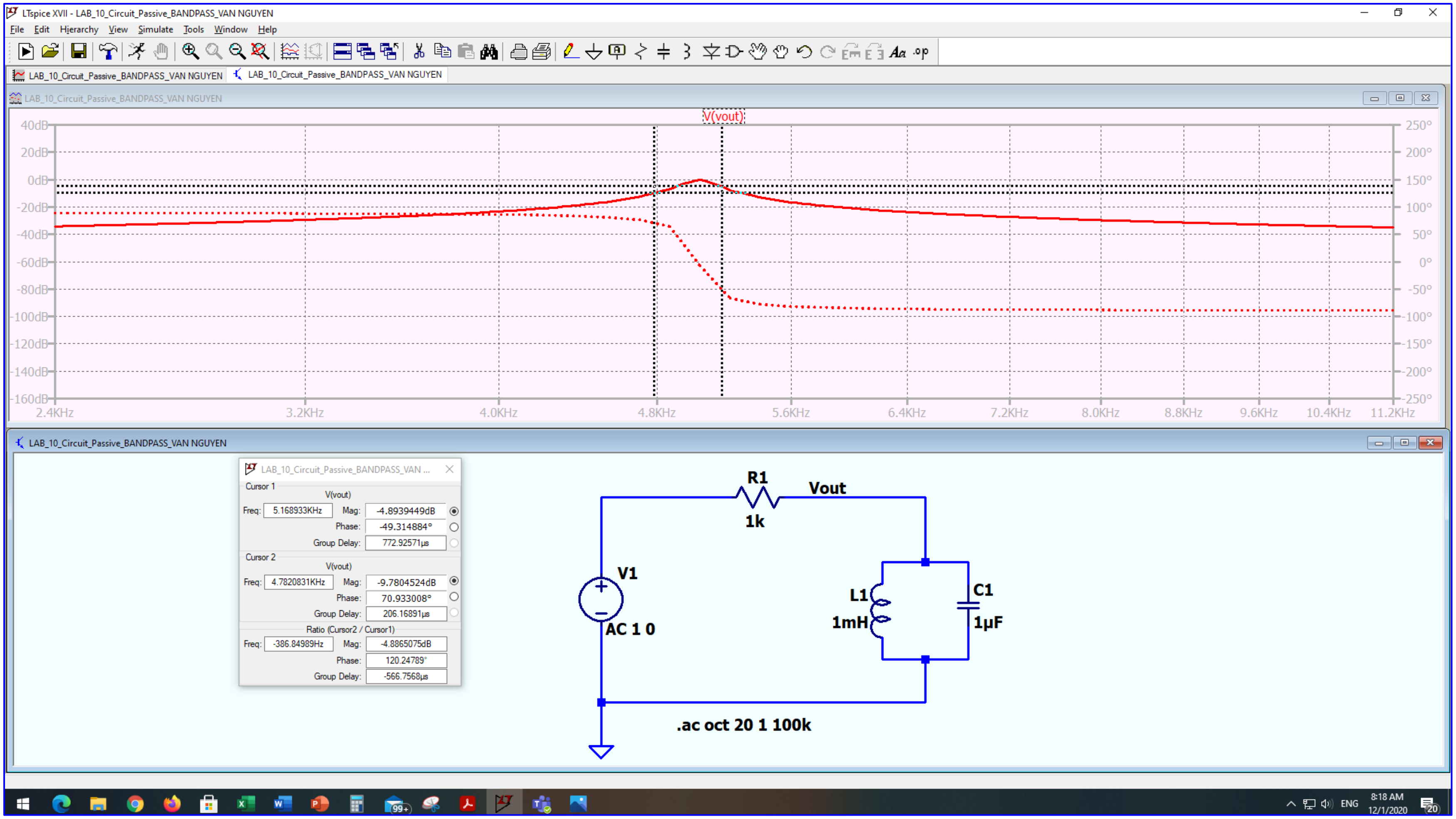
- The center frequency f_0 of the passband is the geometric mean of the following formulas express the three frequencies of the band-pass filter.

BUT if equal-value components are used in implementing each filter, the critical frequency equations simplify to the form

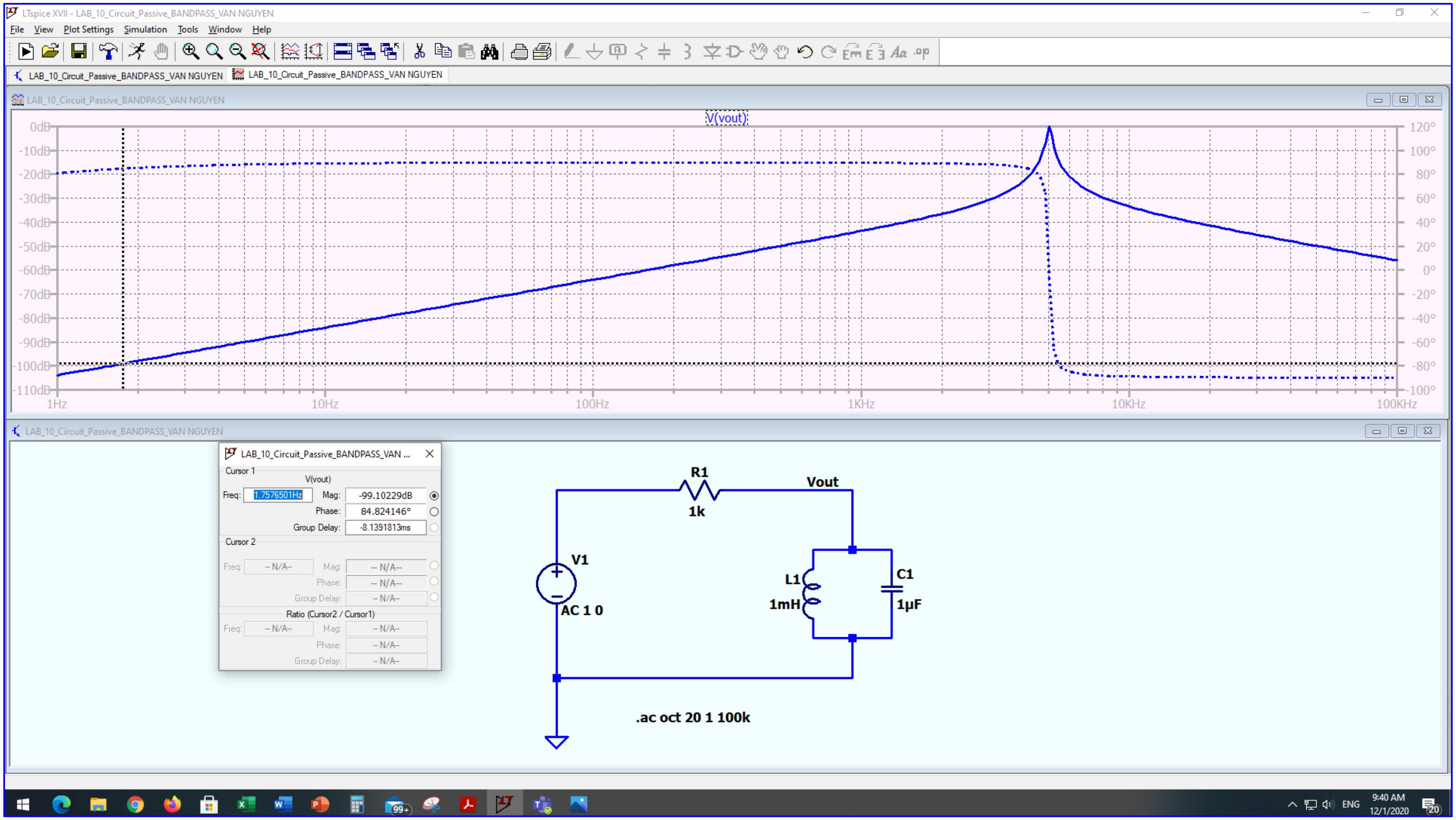
$$\boxed{f_C = \frac{1}{2\pi RC}}$$

- In this LAB, all the values of the ingredients are equal, so we just use a formula of frequency and the same value.

2)-Measure the two critical frequencies and get the bandwidth BW. f_{C2} = 5.12 kHz and f_{C1} = 4.78 kHz



3)- Adjust and test the circuit to get a quarter value f_0 = 1.75 kHz , $f_0 = \sqrt{f_{C1}\, f_{C2}} = \sqrt{(4.78\text{ kHz})(5.12\text{ kHz})}$ = 7 kHz

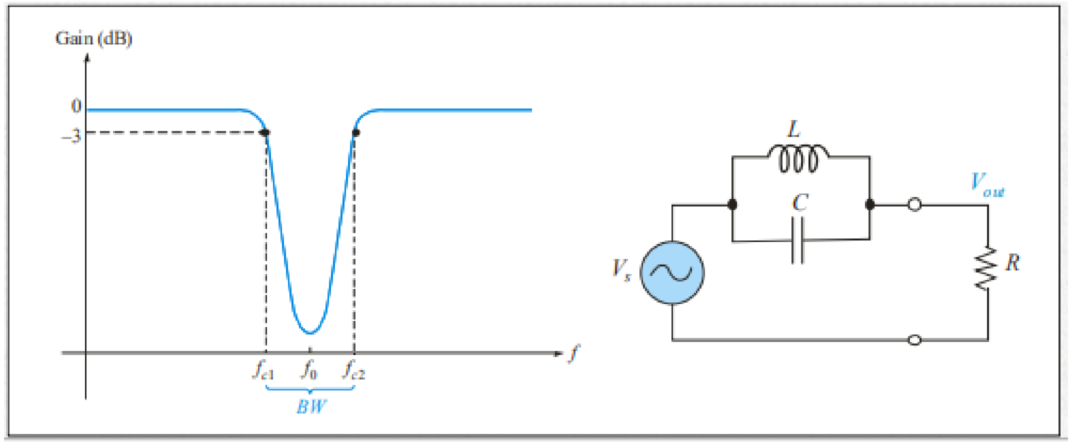


Part 4 : The Band-STOP Filter

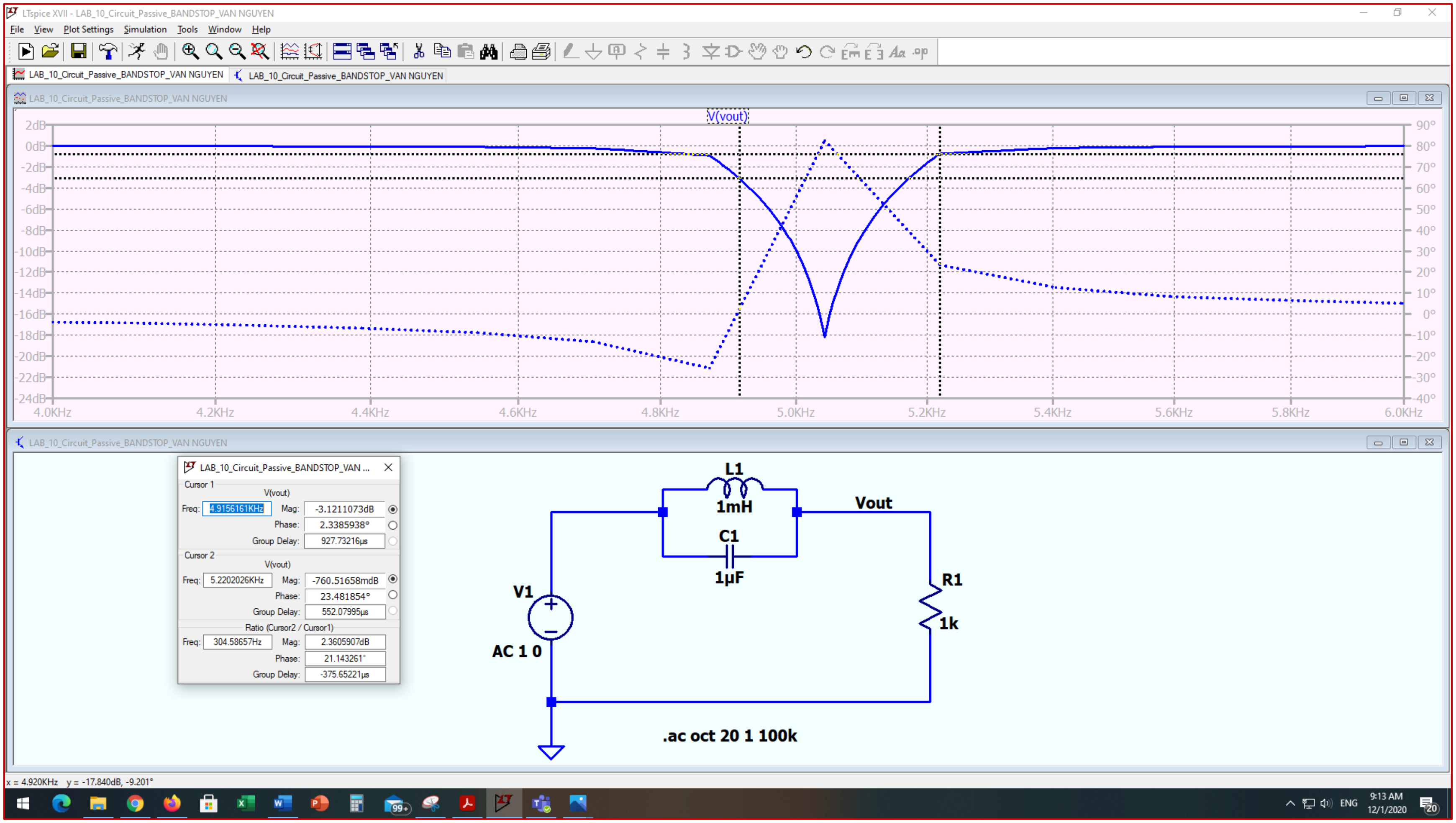
- A band-stop filter rejects frequencies between two critical frequencies; the bandwidth is measured between the critical frequencies. The simplest band-stop filter is an RLC circuit

Implement and simulate passive filters by using RC or RLC circuits with:

- Vs = 1Vp sine wave of frequency 100 Hz and phase 0 degrees.
- R = 1 kΩ
- L = 1 mH
- C = 1 µF



1)- Measure the two critical frequencies and get the bandwidth BW, f_{C1} = 4.9 kHz (-3 dB), f_{C2} = 5.2 kHz (-7 dB),



2)- Adjust and test the circuit to get a third of $f_0 = 5.04$ kHz $\approx f_0 = \sqrt{f_{C1}\, f_{C2}} = \sqrt{(4.9\text{ kHz})(5.2\text{ kHz})}$ = **5.04 kHz**

We can't measure a third of f_0 in this circuit .