CENTRAL CONNECTICUT STATE UNIVERSTY

SCOOL OF ENGINEERING,

SCIENCE, AND TECHNOLOGY

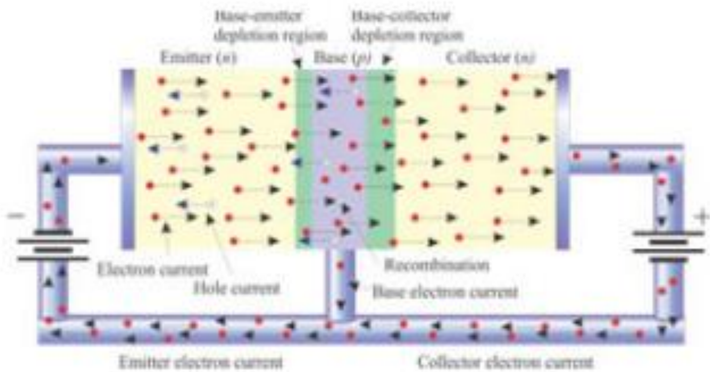
1615 Stanley St., New Britain,

CT - 06050

Chapter 15_ LAB_11

REPORT_Active Filters SIMULATION

2-pole & 4 -pole



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

Computer engineering Technology

From: **Van Thi Minh Nguyen**

CET 323_01 CRN: 11342

December 10th , 2020

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CET 323 LAB

Dr. Park

Date December 10th , 2020.

Class CET 323_01

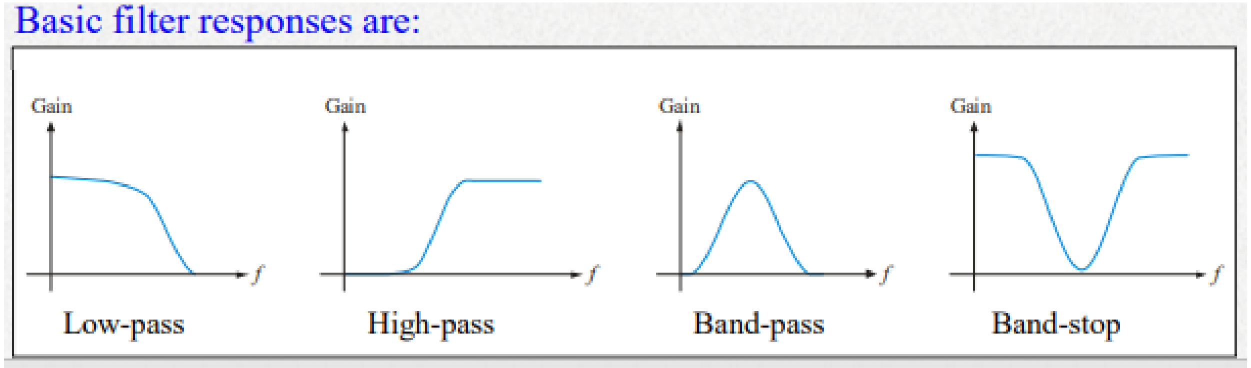
Name Van Nguyen

LAB_11

Active Filters SIMULATION

Reading

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



❖ In this lab, you will implement and simulate the following two filters using Sallen-Key filter configurations involving RC pairs

- 2-pole Low-pass Butterworth filter
- 4-pole High-pass Butterworth filter

The Damping Factor

Parameters for **Butterworth filters** up to four poles are given in the following table. (See text for larger order filters).

Butterworth filter values

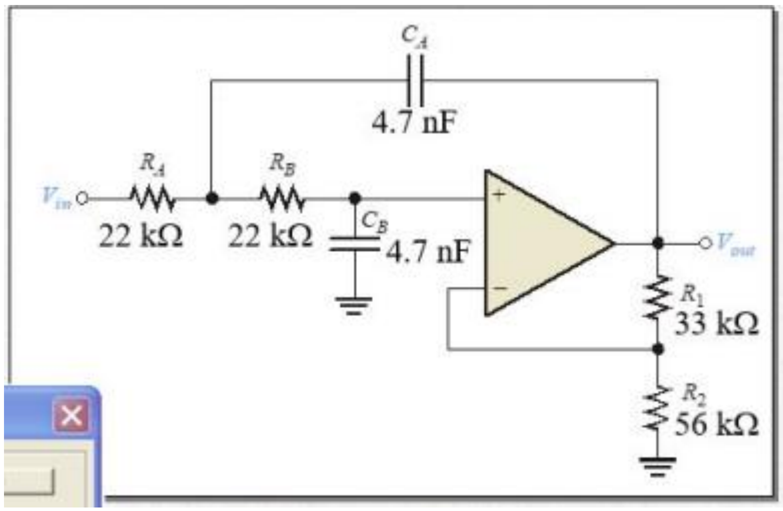
Order	*Roll-off dB/decade*	*1st stage*			*2nd stage*		
		Poles	*DF*	*R_1/R_2*	*Poles*	*DF*	*R_1/R_2*
1	–20	1	*Optional*				
2	–40	2	1.414	0.586			
3	–60	2	1.00	1.00	1	1.00	1.00
4	–80	2	1.848	0.152	2	0.765	1.235

Notice that the gain is 1 more than this resistor ratio. For example, the gain implied by this ratio is 1.586 (4.0 dB).

Part 1 : Low-Pass Butterworth filter.

- Implement 2-pole Low-Pass Butterworth filter:

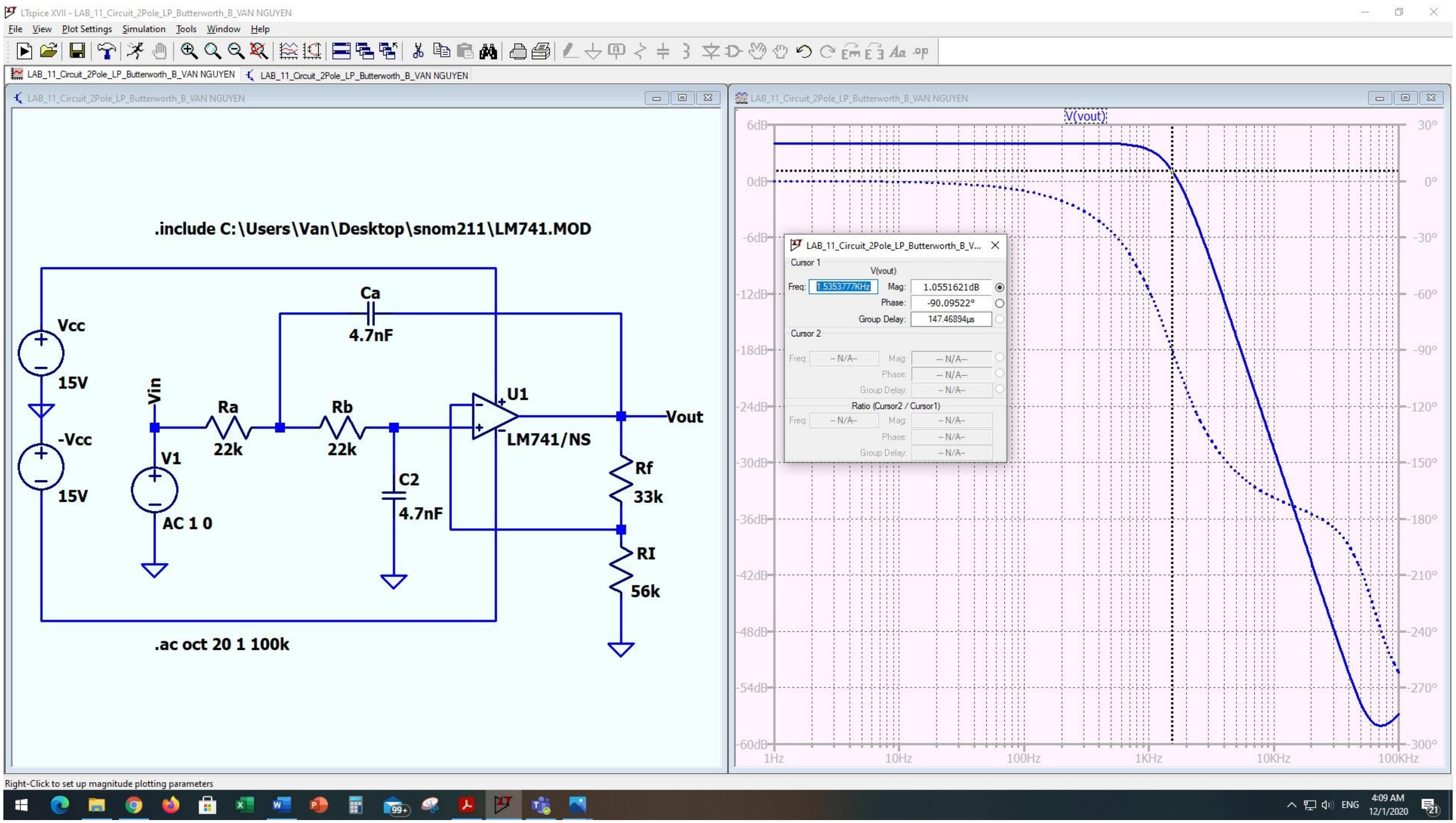
Two pole 2-pole Low Pass Butterworth Design



1)- Calculate critical frequency.

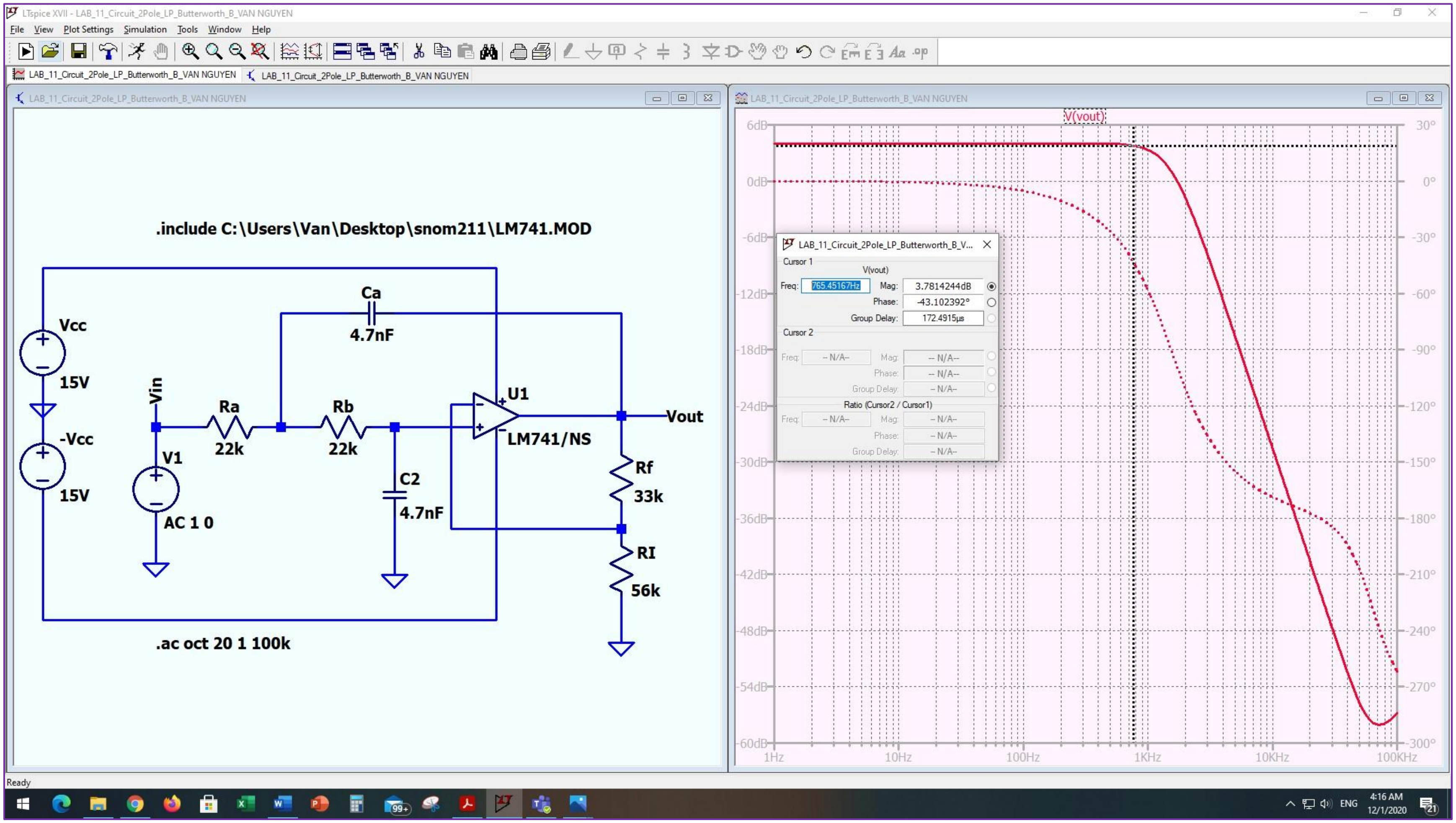
$$f_C = \frac{1}{2\pi RC} = \frac{1}{2(3.1416)(1\ \text{k}\Omega)(1\ \mu\text{F})} = 159\ \text{Hz}$$

1) Lab_circuit_2Pole_LP_Butterworth_A_LM741 (f_c = 1.535 kHz)



2)- Lab_circuit_2Pole_LP_Butterworth_B_LM741

Half fc values = 765 Hz. Bandwidth is measured between the 0.707 current amplitude points.



Part-2: Low-Pass Filtering of Noisy Signal

Generate a heterogeneous signal mixture for Low-Pass filtering

- Use your previous Summing Amplifier to make an arbitrary signal generator.
- Arbitrary Signal Generate can produce arbitrary mixture signal by using multiple sinusoids with different amplitudes, frequency, and phases.
- Let your arbitrary signal generator make a composite waveform by using the following three input component signals;
  - Vin1 = 1Vp sine wave with 1 kHz frequency and zero-degree phase shift
  - Vin2 = 1Vp sine wave with 10 kHz frequency and zero-degree phase shift
  - Vin3 = 1Vp sine wave with 20 kHz frequency and zero-degree phase shift

Simulate for Transient Analysis

Verify your filter operation by simulating its waveform graph that shows the output and the input of the filter in one graph as follows:

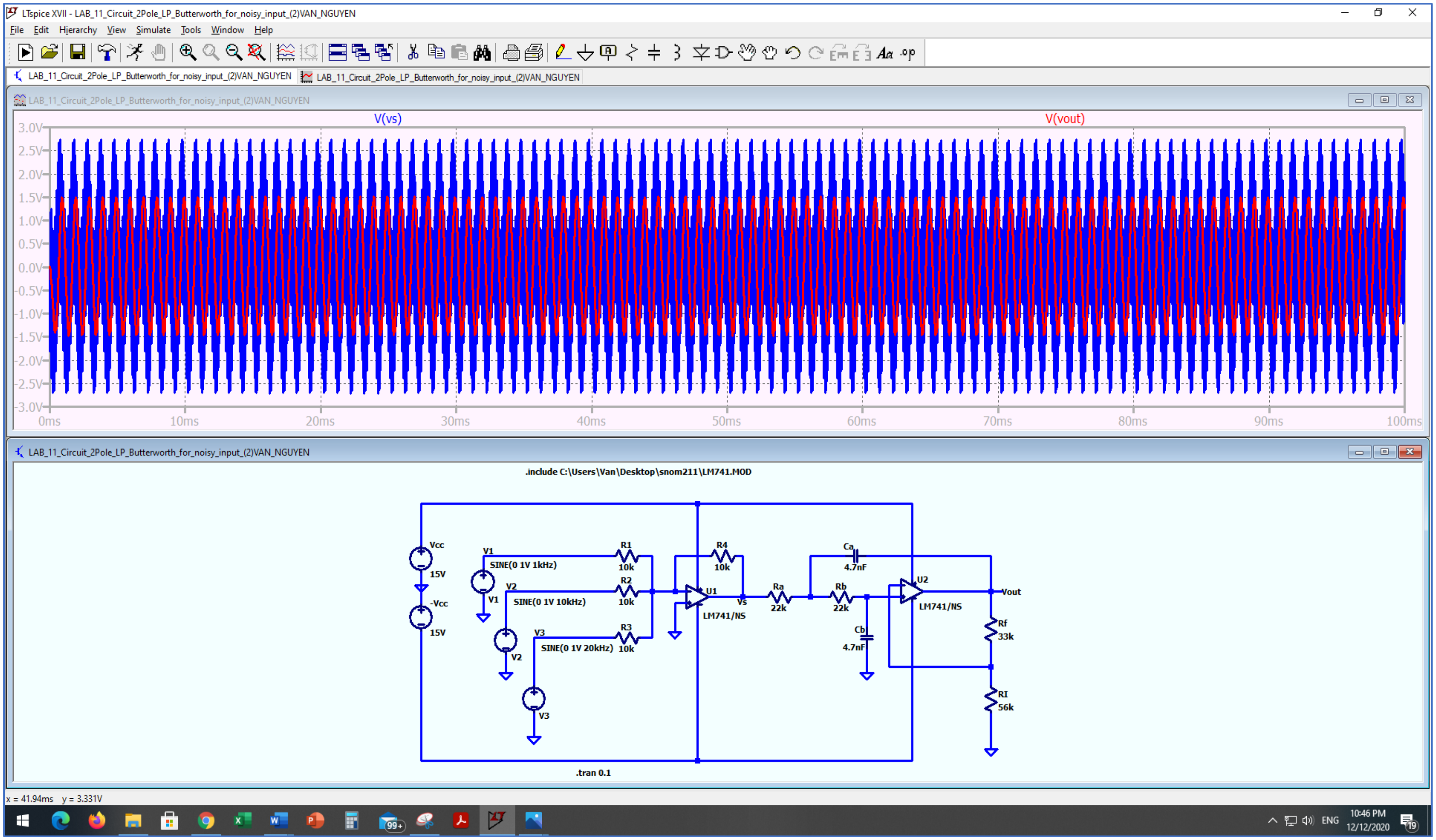
• $V_{\mathbf{OUT}}$

• $V_{\mathbf{in}}$ •

Edit Simulation Command for Transient Analysis (Waveform Plot) as **“.tran 0.1”**

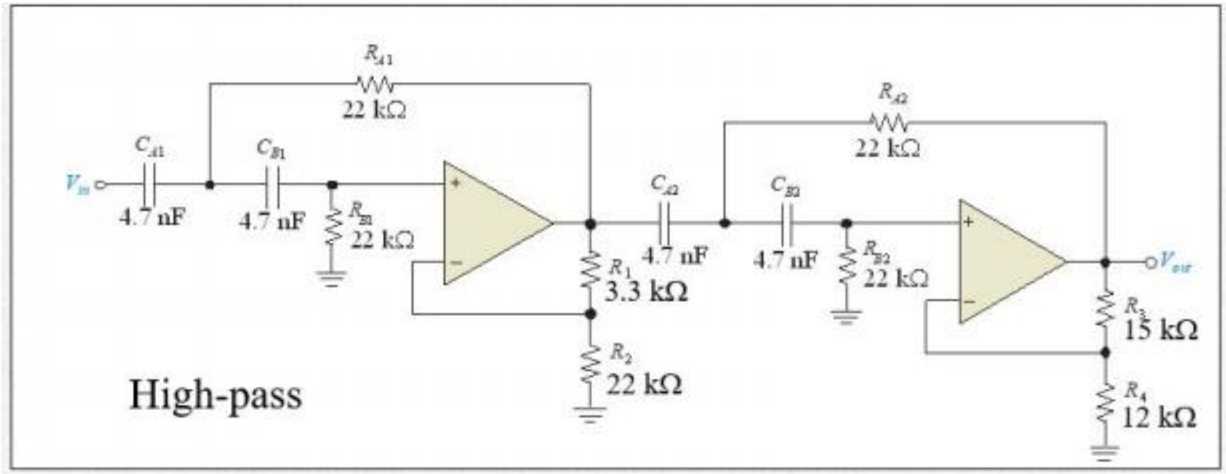
Capture the waveform graph and the schematic in one shot:

1)- Lab_simulate_2Pole_LP_Butterworth_for_noisy_input (V_{out} , V_{in}, . tran 0.1)

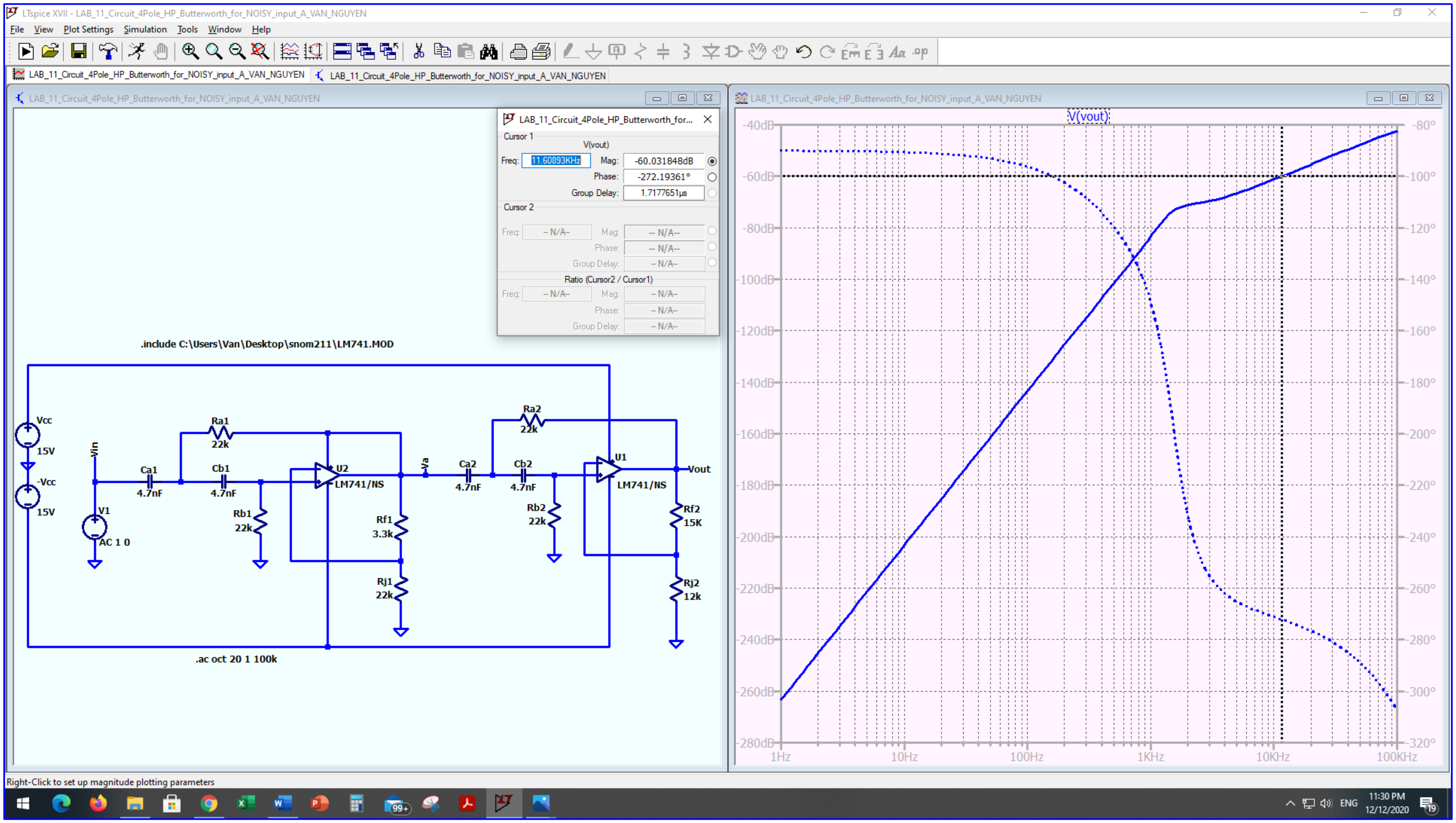


Part-3: High-Pass Butterworth filter

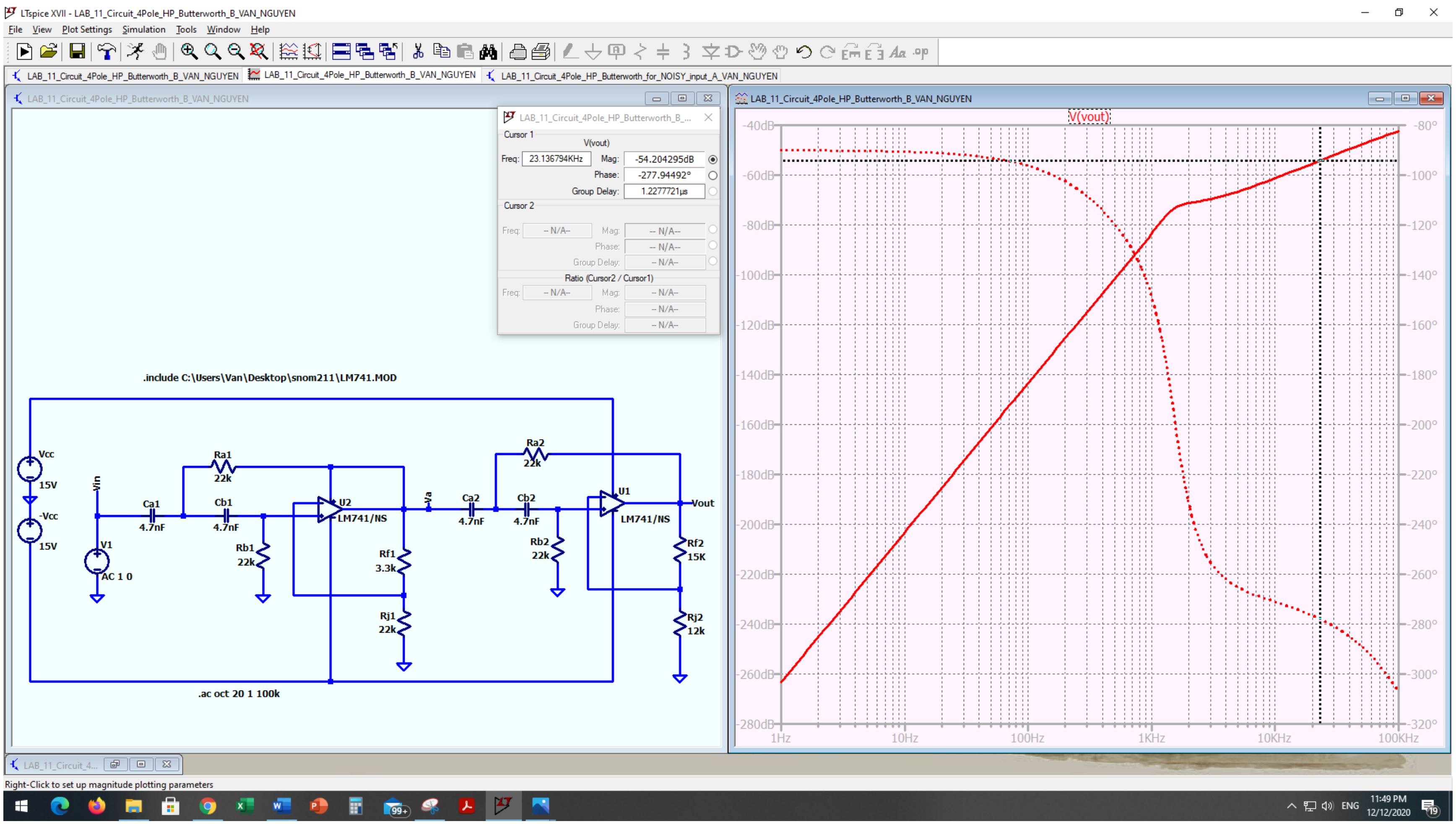
Implement 4-pole High-Pass Butterworth filter:



• Lab_circuit_4Pole_HP_Butterworth_A; Measure critical frequency by simulation f_c = 11.6 kHz at -60 dB



- Lab_circuit_4Pole_HP_Butterworth_B ; Measure critical frequency _**twice fc value.**= 23.1 kHz at -54.2 dB



Part-4: High-Pass Filtering of Noisy Signal

Generate a heterogeneous signal mixture for High-Pass filtering

You will modify the input signal mixture as follows.

Use your previous Summing Amplifier to make an arbitrary signal generator.

Arbitrary Signal Generate can produce arbitrary mixture signal by using multiple sinusoids with different amplitudes, frequency, and phases

Let your arbitrary signal generator make a composite waveform by using the following three input component signals;

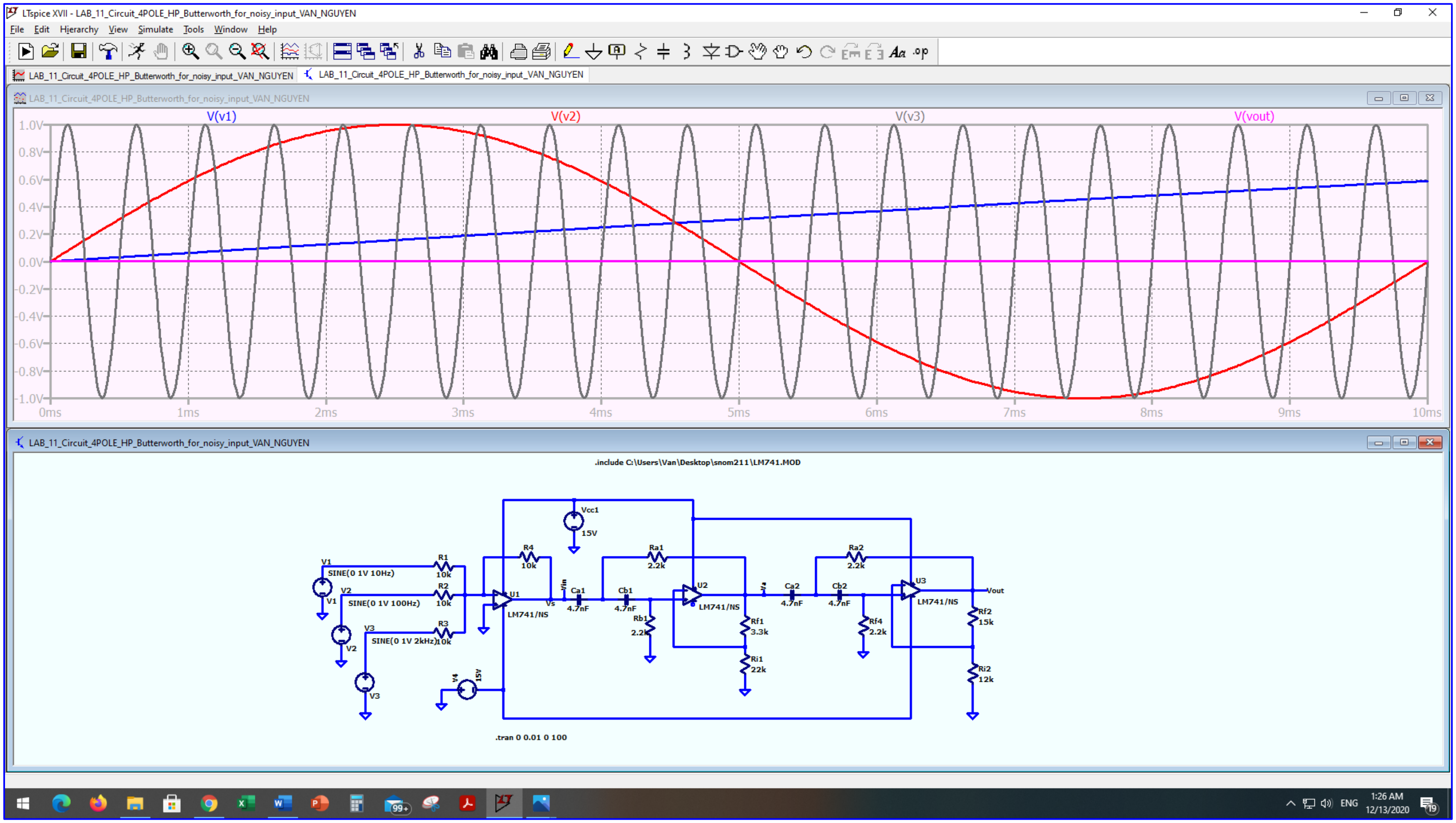
- Vin1 = 1Vp sine wave with 10 Hz frequency and zero-degree phase shift
- Vin2 = 1Vp sine wave with 100 Hz frequency and zero-degree phase shift
- Vin3 = 1Vp sine wave with 2 kHz frequency and zero-degree phase shift

Simulate for Transient Analysis Verify your arbitrary signal generator by simulating its waveform graph that shows the output and the three inputs in one graph as follows:

- V_{OUT}
- Vin1
- Vin2
- Vin3

Capture the waveform graph and the schematic in one shot, and save it as

Lab_Circuit_4Pole_HP_Butterworth_for_noisy_input (With V_1, V_2, V_2 and V_{out})



Apply 4-Pole High-pass Butterworth Filter

Use your 4-pole High-Pass Butterworth filter to pass only the highest-frequency signal component and stop the remaining signal components.

Connect the arbitrary signal generator output to the input of your lowpass filter.

Simulate for Transient Analysis

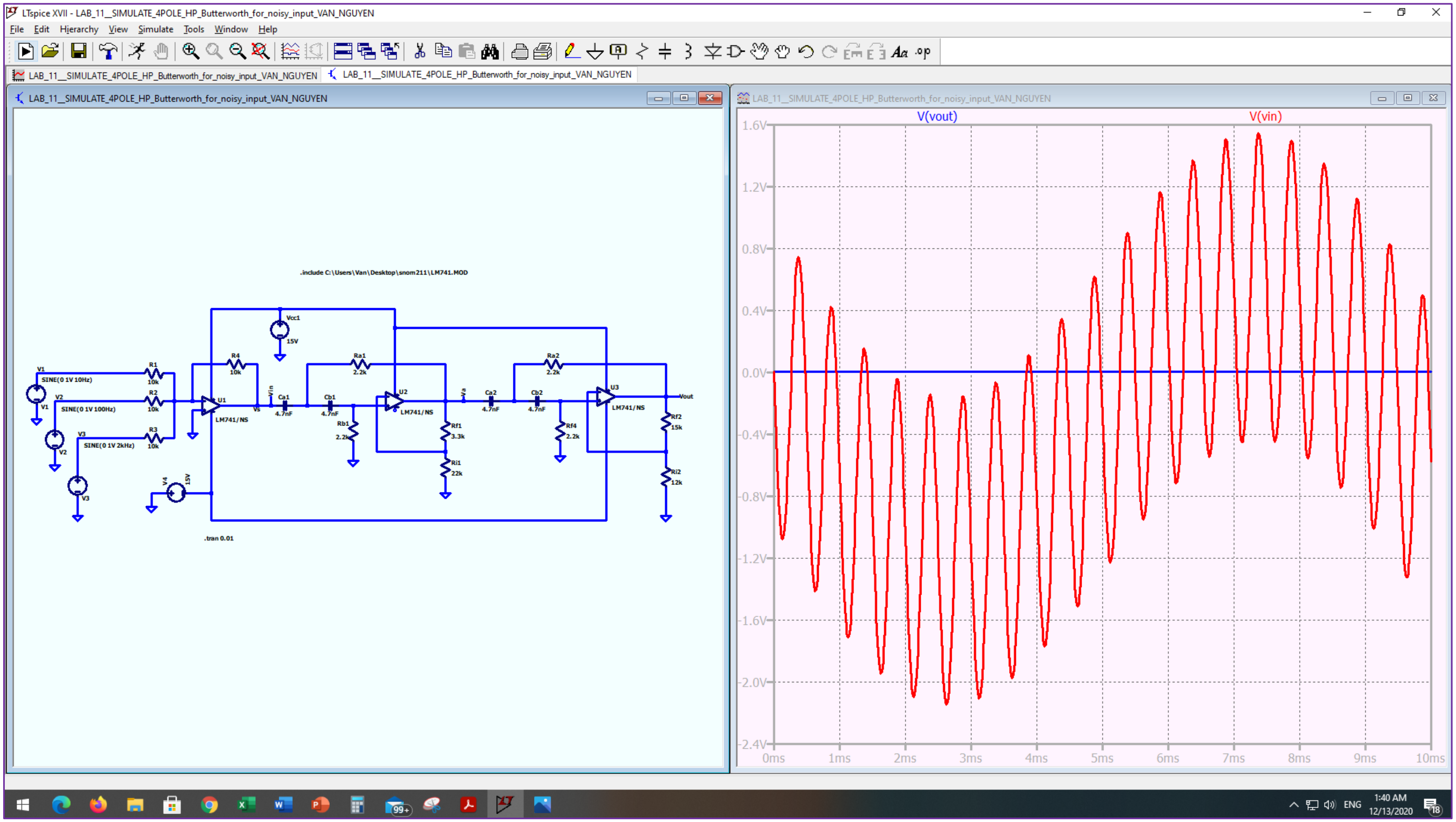
Verify your filter operation by simulating its waveform graph that shows the output and the input of the filter in one graph as follows:

- V_{OUT}
- V_{in}

Edit Simulation Command for Transient Analysis (Waveform Plot) as **".tran 0.01"**

Capture the waveform graph and the schematic in one shot:

Lab_Simulate_4Pole_HP_Butterworth_for_noisy_input (With Vout, Vin and ".tran 0.01")



Lab_Simulate_HP_Butterworth_for_noisy_input_ 2Pole & 4Pole (With V_{out}, V_{in})