**CENTRAL CONNECTICUT STATE UNIVERSTY**

**SCOOL OF ENGINEERING,**

**SCIENCE, AND TECHNOLOGY**

**1615 Stanley St., New Britain,**

**CT - 06050**

☎

# Chapter 13_BASIC OP-OMP

# LAB_09

## Circuit Op Amp Summing Amplifiers, plus Comparator and plus Schmitt Trigger


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

**Computer engineering Technology**

***From*****: Van Thi Minh Nguyen**

**CET 323_01 CRN: 11342**

**November 24th , 2020**

**---✶✶✶---**

CET 323 LAB

Dr. Park

Date November 24th , 2020.

Class CET 323_01

Name Van Nguyen

# LAB_09

# SIGNAL PROCESSING WITH OP AMP

## Reading

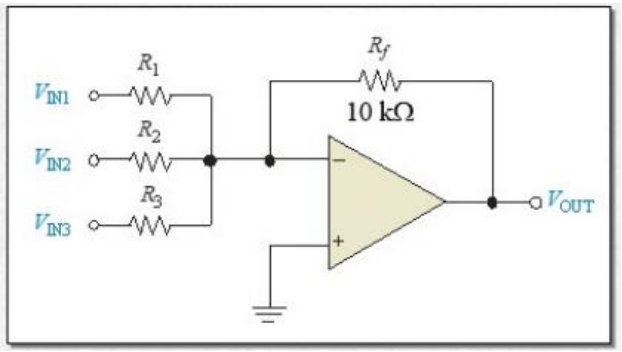
Floyd, Electronic Devices, Ninth Edition, Chapter 13.

## Part 1 : Summing Amplifier

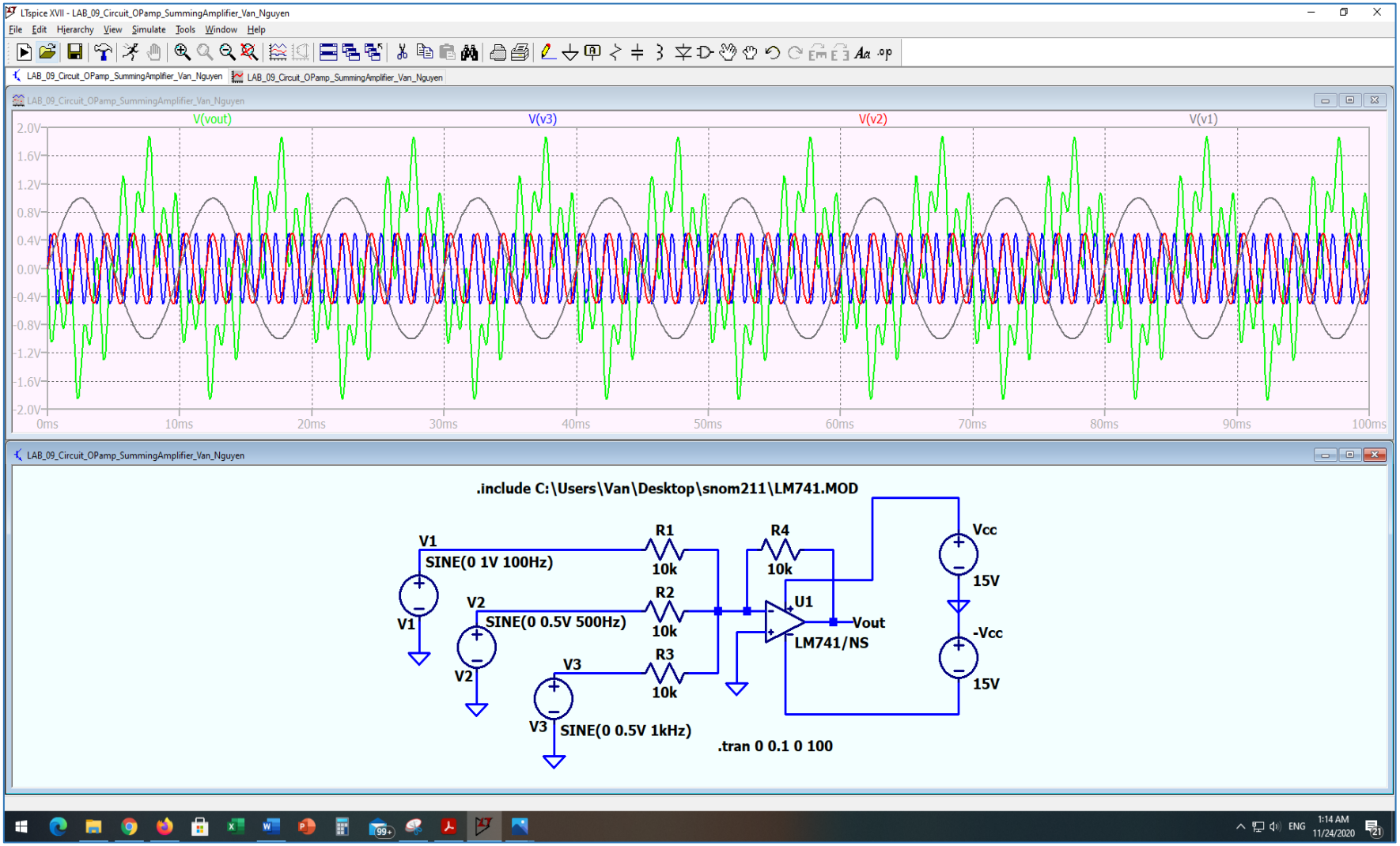
Modify $V_{in1}$, $V_{in2}$, $V_{in3}$ as follows;

- $V_{in1}$ = 1Vp, 100Hz sine wave
- $V_{in2}$ = 0.5Vp, 500Hz sine wave
- $V_{in3}$ = 0.5Vp, 1kHz sine wave

**Figure 9_1**



1. Simulate for Analysis_ Summing Amplifier_ waveform graph of $V_{in1}$,$V_{in2}$,$V_{in3}$ and $V_{out}$,



***Discussion Questions* _ Part 1**:

1)- Analyze and interpret your simulation data (i.e., waveform.)

- Using implement the "following Summing Amplifier", with three inputs $V_{in1}$, $V_{in2}$ and $V_{in3}$ for to practice signal generation and error embedding to signal handling to output and modify it to make an arbitrary signal.

2)- How can an arbitrary waveform be generated by using an OP Amp?

- Arbitrary Signal Generate is produces arbitrary noisy signal by using multiple sinusoids with different amplitudes, frequency, and phases. Usually all the inputs have unity gain. The output is proportional to the negative of the algebraic sum of the input.

  So just need change the values of the inputs then we will generate arbitrary signals.

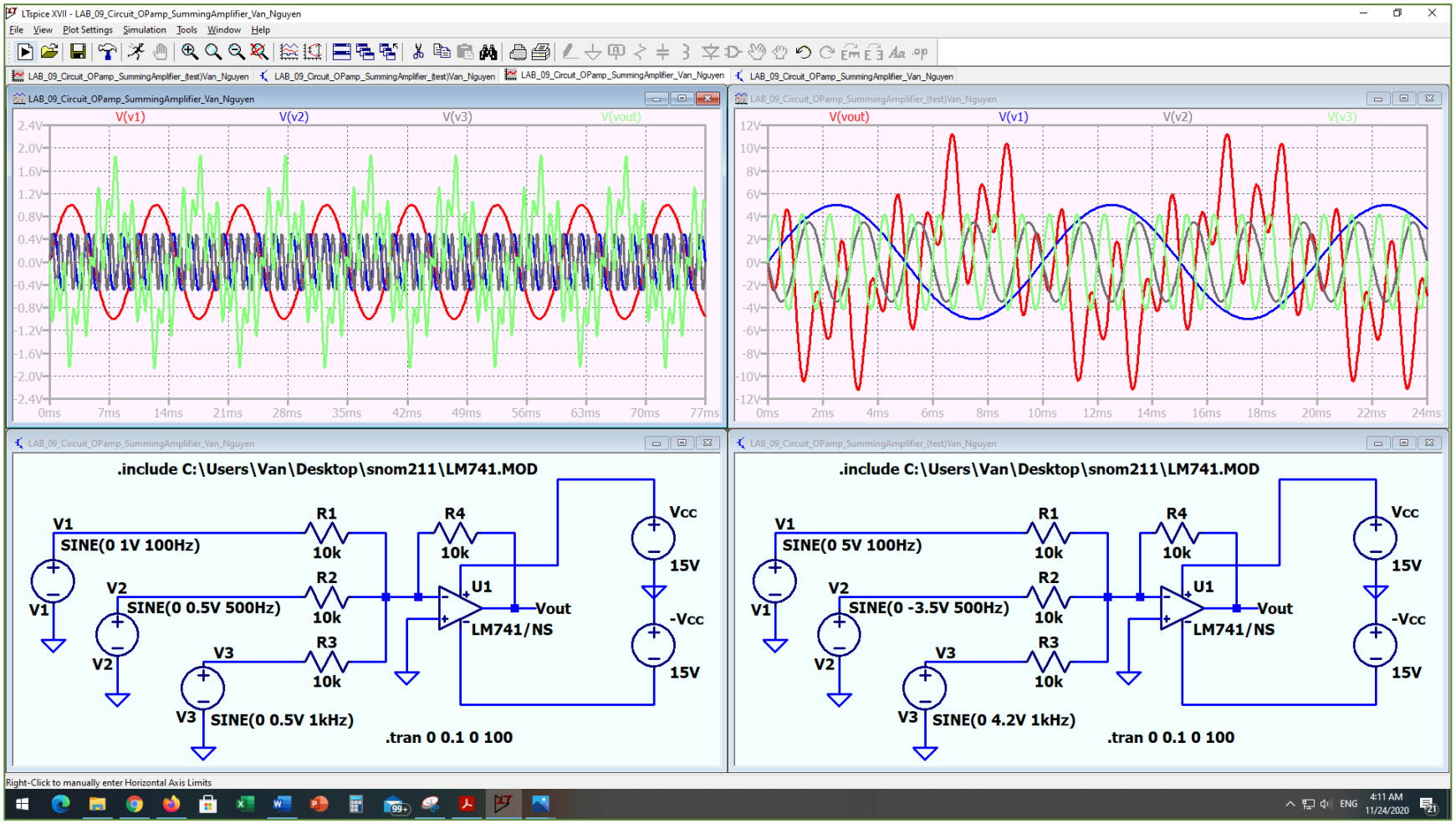
3)- Identify the relevant formula.

- Example, from figure 9_1. If we change values voltage input of $V_{in1}$ = +5.0 V, $V_{in2}$ = - 3.5 V and $V_{in3}$ = +4.2 V , and not change value of resistors, they still are 10 kΩ.
- We have $V_{out}$ is : $V_{out} = -(V_{in1} + V_{in2} + V_{in3}) = -( +5\ V +(-3.5\ V ) + 4.2\ V = -\ 5.7\ V$

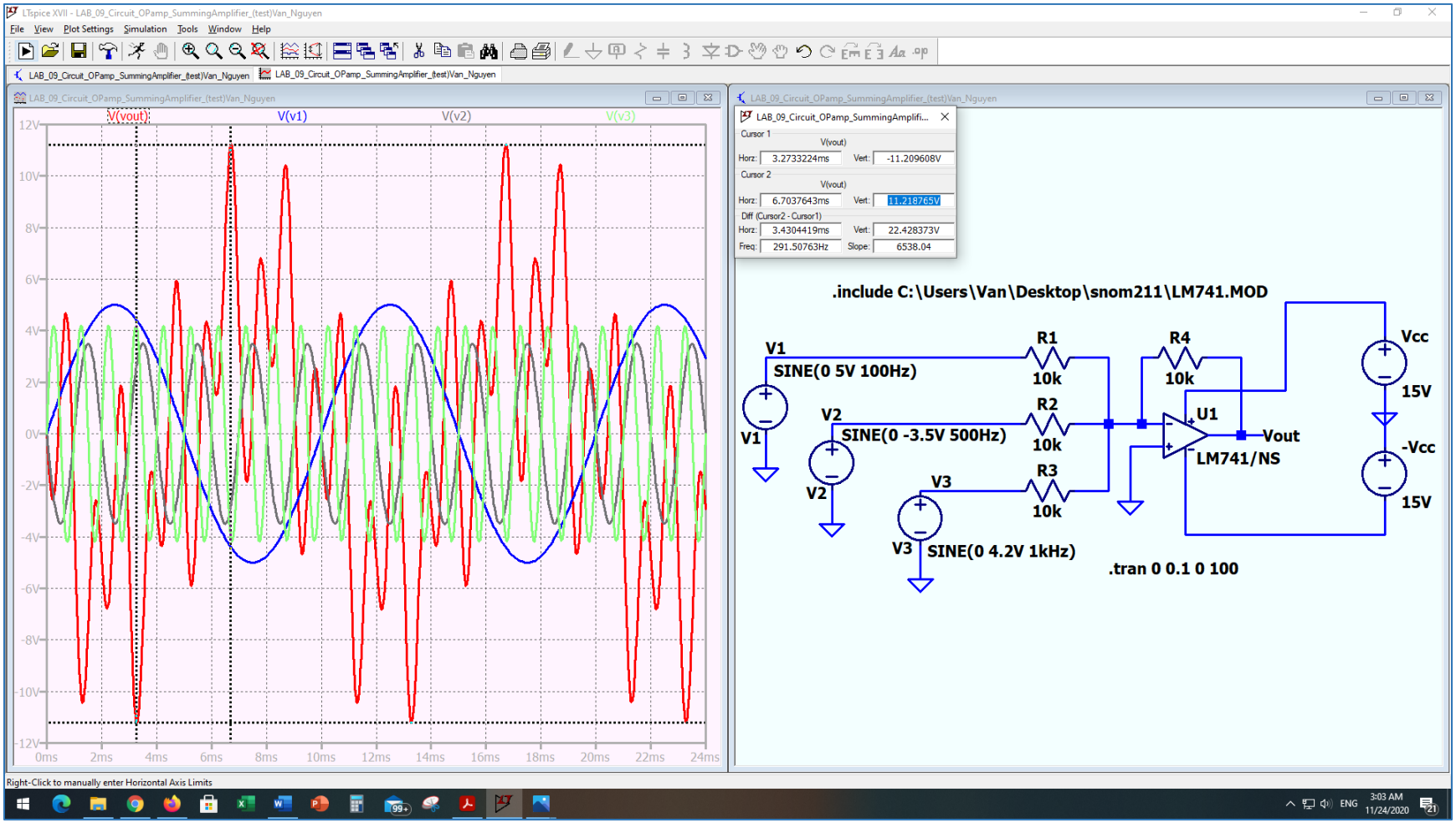
⇨ $V_{out} = -\ 5.7\ V$

- We will check signal by simulation waveform.

❖ The waveforms are different when we change the values Voltage of the inputs.



❖ **Measure value Voltage of output when change the values Voltage of the inputs.**

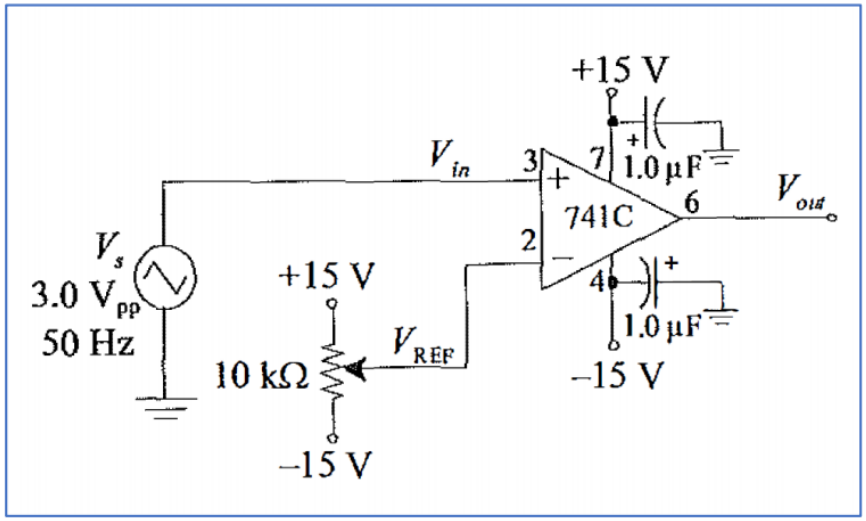


## **Part 2**: Summing Amplifier plus Comparator

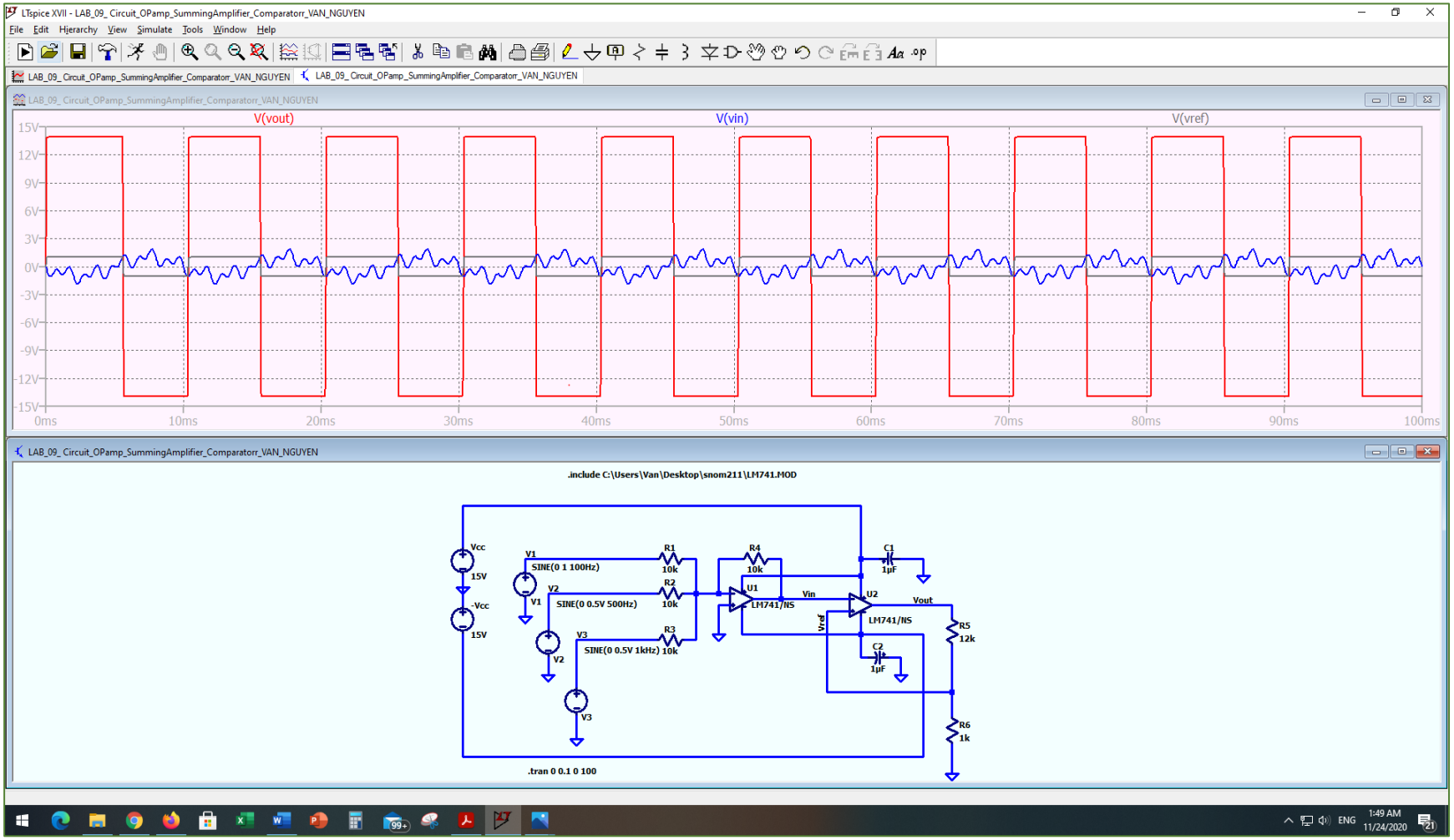
Use the same method as Part-1. Your waveform graph should include (i.e., probe) the output, the input, and the reference voltage

VREF at the inverting input of the comparator as follows:

- $V_{out}$
- $V_{in}$
- $V_{REF}$



2. Simulate for Analysis_Summing Amplifier plus Comparator _ Waveform graph of $V_{out}$, $V_{in}$ and $V_{REF}$



***Discussion Questions:***

1)- Analyze and interpret your simulation data (i.e., waveform.)

- The output is negative when the input is a positive-going ramp and positive when the input is a negative-going ramp.
- The output voltage is the same frequency as the reference voltage but differs in the oscillation amplitude,
- Input signal is analogue , so waveform typical Electrical Waveform, has small, serrated shape, not even, but the output behaves digitally is the Signal waveforms, as square waveform.

2)- Explain the role of the comparator.

- The comparators to be resistor in series to reduce high frequency noise.
- The op-amp voltage comparator compares the magnitudes of two voltage inputs and determines which is the largest of the two and produces an output signal based on this voltage comparison.
- Input signal is analogue, but the output behaves digitally.
- Comparators operate with open-loop gain.

3)- How is the output pattern different from the situation in which a single pure sine wave is used as input?

The output is the Signal waveforms, such as square waveform, Signal Waveforms such as Square Waves, Rectangular Waves.

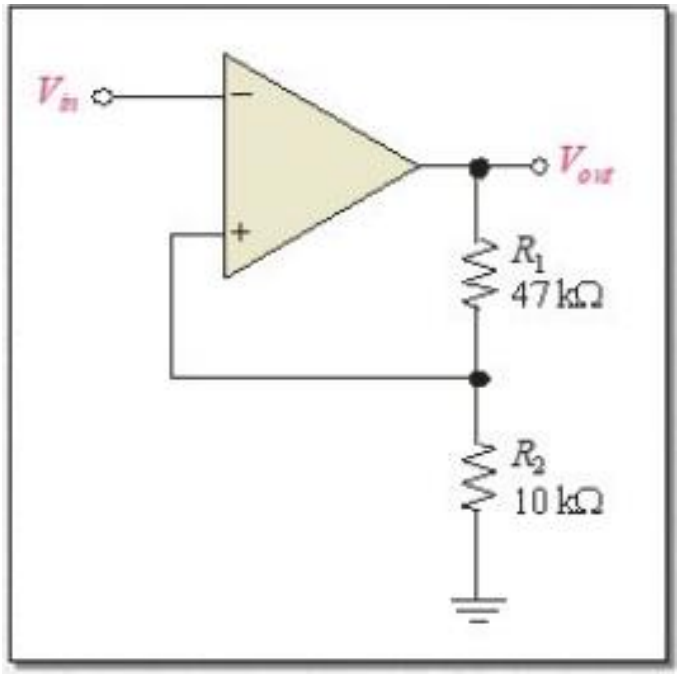
4)- Explain the reason.

Because it is op-amp voltage comparator to be plus , to compares the magnitudes of two voltage inputs to give output Signal Waveforms, so the input often is an oscillator with two or more two inputs.

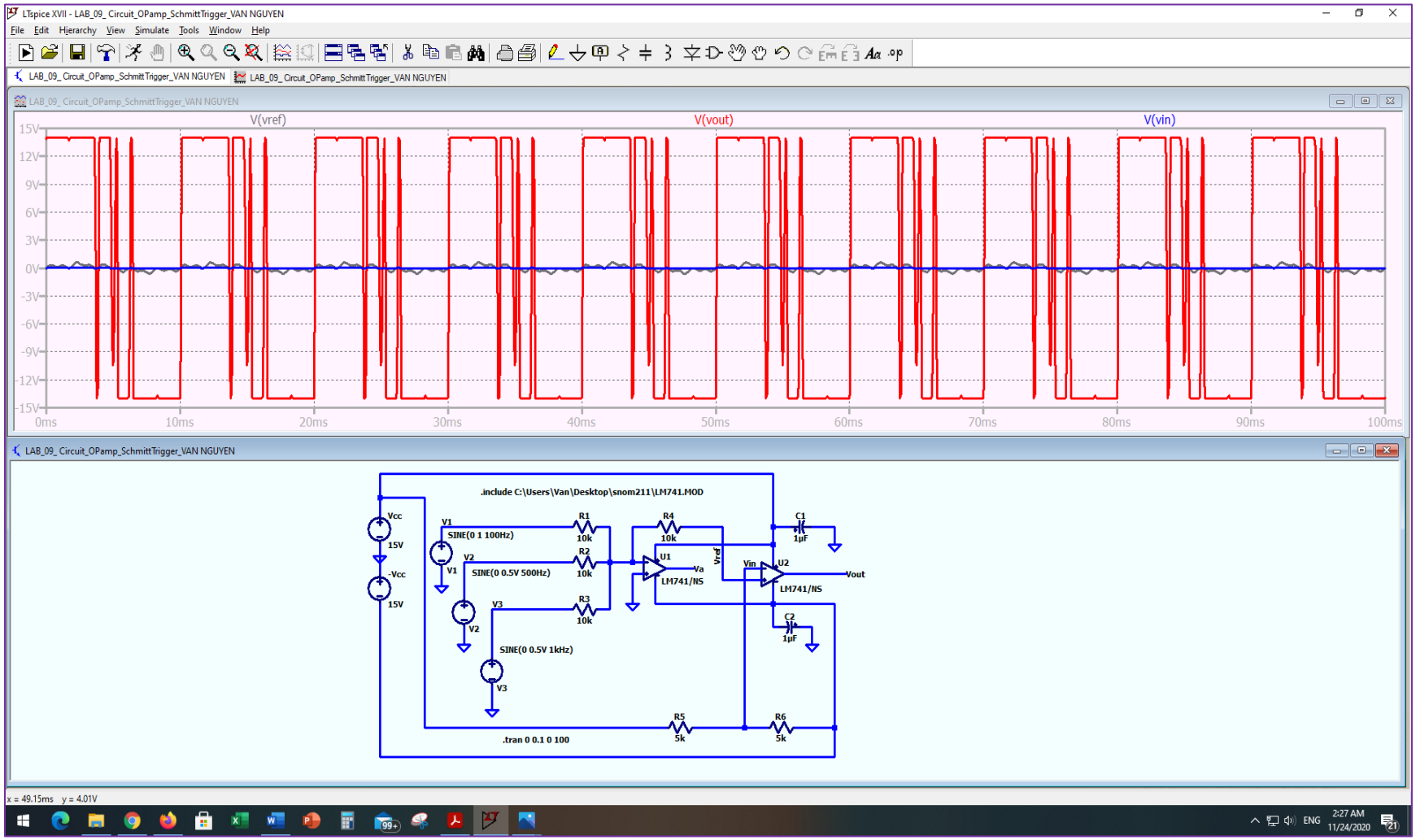
## **Part 3**: Summing Amplifier plus Schmitt Trigger

Use the same method as Part-1. Your waveform graph should include (i.e., probe) the output, the input, and the reference voltage VREF at the noninverting input of the Schmitt Trigger as follows:

- $V_{out}$
- $V_{in}$
- $V_{REF}$



3) Simulate for Analysis_ Summing Amplifier plus Schmitt Trigger _ Waveform graph of $V_{out}$, $V_{in}$ and $V_{REF}$



## Discussion Questions:

1)- Analyze and interpret your simulation data (i.e., waveform.)

- Waveform of input (0 V) is a straight line, constant, the output behaves digitally is the Signal waveforms, square waveform has going ramp; Frequency fluctuates quickly and slowly; The output signal that is in phase to the non-inverting input .

2)- Explain the difference of the outputs from comparator versus Schmitt Trigger.

- We can see that the op-amp voltage comparator is a device whose output is dependent on the value of the input voltage,

  If $V_{in} > V_{REF}$ then $V_{out} = +V_{cc}$ or If $V_{in} < V_{REF}$ then $V_{out} = -V_{cc}$

- In theory due to the op-amps high open-loop gain the magnitude of its output voltage could be infinite in both directions, ($\pm\infty$). However practically, and for obvious reasons it is limited by the op-amps supply rails giving $V_{OUT} = +V_{CC}$ or $V_{OUT} = -V_{CC}$.
- One way to overcome this problem and to avoid the op-amp from oscillating is to provide positive feedback around the comparator. It is a technique for feeding back a part of the output signal that is in phase to the non-inverting input of the op-amp via a potential divider set up by two resistors ($R_1$ and $R_2$)with the amount of feedback being proportional to their ratio, called a **Schmitt trigger circuit**

3)- Explain how Schmitt Trigger works.

- $V_{IN}$ is applied to the inverting input of the op-amp.
- Resistors $R_1$ and $R_2$ form a voltage divider network across the comparator providing the positive feedback with part of the output voltage appearing at the non-inverting input.

4)- Identify the relevant formula.

- The amount of feedback is determined by the resistive ratio of the two resistors used and which is given as:

$$V_{UTP} = \frac{R_2}{R_1 + R_2}(+V_{CC}) \quad \textit{or} \quad V_{LTP} = \frac{R_2}{R_1 + R_2}(-V_{CC})$$

- Observe and compare waveform graph of Circuit Op Amp Summing Amplifiers , plus Comparator and plus Schmitt Trigger .