جامعة بيرزيت

BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

CIRCUITS AND ELECTRONICS LABORATORY– ENEE2103

Experiment No. 10 Prelab

The Operational Amplifier

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Section: 4

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Prelab instructions:

1. Simulate the circuits in the procedure section and determine the required values (set the parameters that must be assigned by the instructor in the procedure to proper values).

2. Verify if Simulation Results match the expected results

Procedure and Discussion

Part 1: Adding Application

the circuit has been sat up, V1 is controlled by the potentiometer and V2, is obtained from the variable dc source on the trainer.

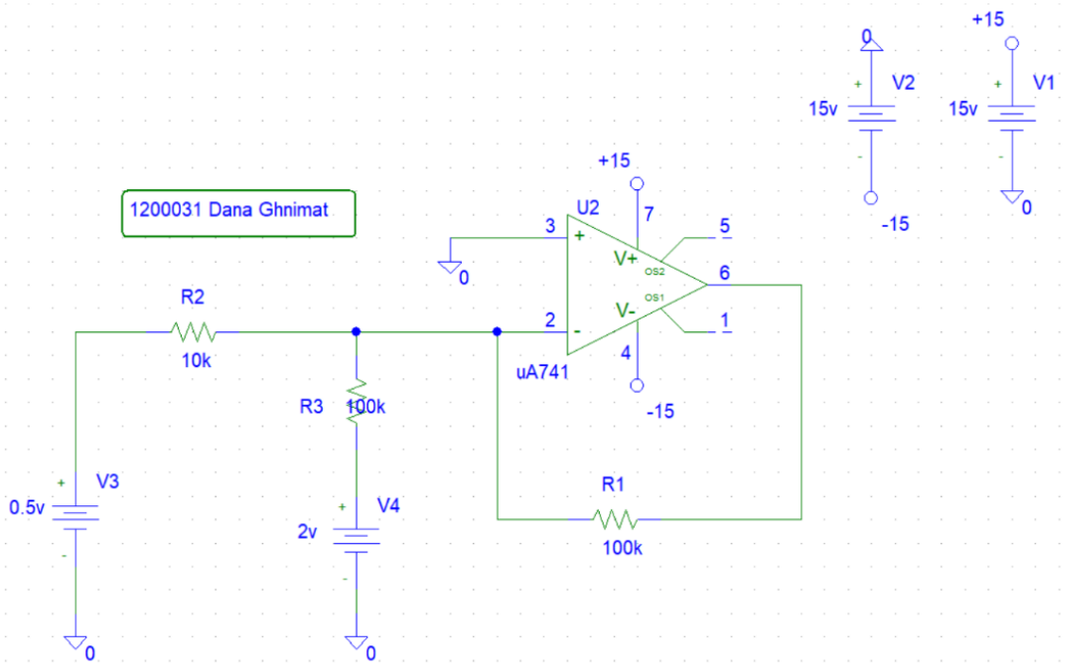

Figure 1 Adding Application Circuit

Simulation:

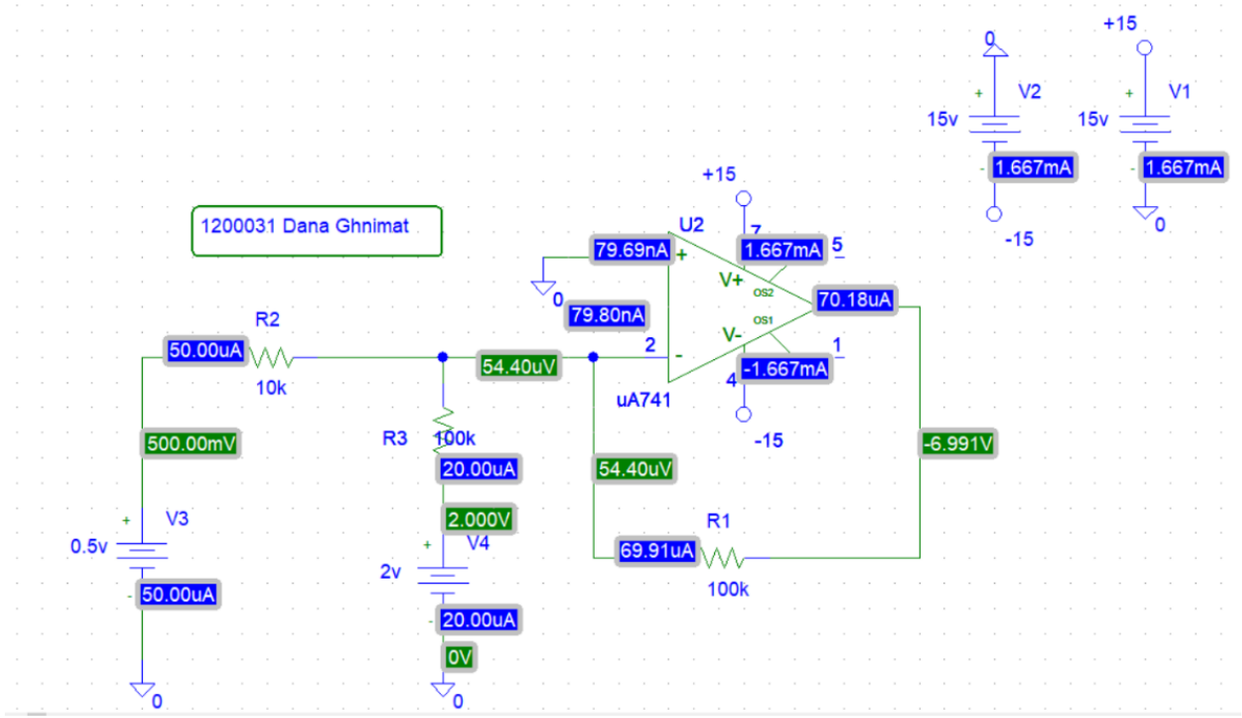

Figure 2 Adding Application Circuit Simulation

$$Vo = -\left(\frac{R_F}{R_1} V_1 + \frac{R_F}{R_2} V_2\right)$$
$$-\left(\frac{100k}{10k} V_1 + \frac{100k}{100k} V_2\right)$$
$$Vo = -(10 V_1 + V_2)$$

Table 1 Output Voltage

Input Voltage		Output Voltage	
V_1	V_2	Vo	Calculated value
0.5	**2**	-6.991	− (10(0.5) + 2) = −7
0.3	**4**	-6.991	− (10(0.3) + 4) = −7
0.1	**6**	-6.991	− (10(0.1) + 6) = −7
-0.9	**2**	7.008	− (10(-0.9) + 2) = 7
-1.1	**4**	7.008	− (10(-1.1) + 4) = 7
-1.3	**4**	9.008	− (10(-1.3) + 4) = 9
-1.5	**6**	9.008	− (10(-1.5) + 4) = 9

Part 2: Voltage Follower Application

After the circuit has been sat:

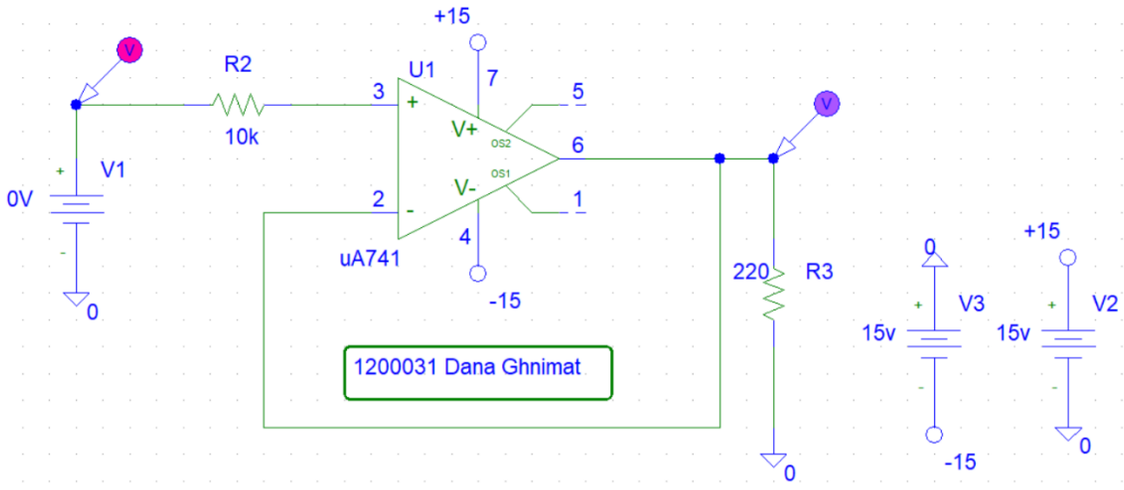

Figure 3 Voltage Follower Application when RL = 220Ω

To get the input and output voltage relation DC sweep has been used to records Vo for a dc input Vi = (1 to 20V) using with a step of 1V.

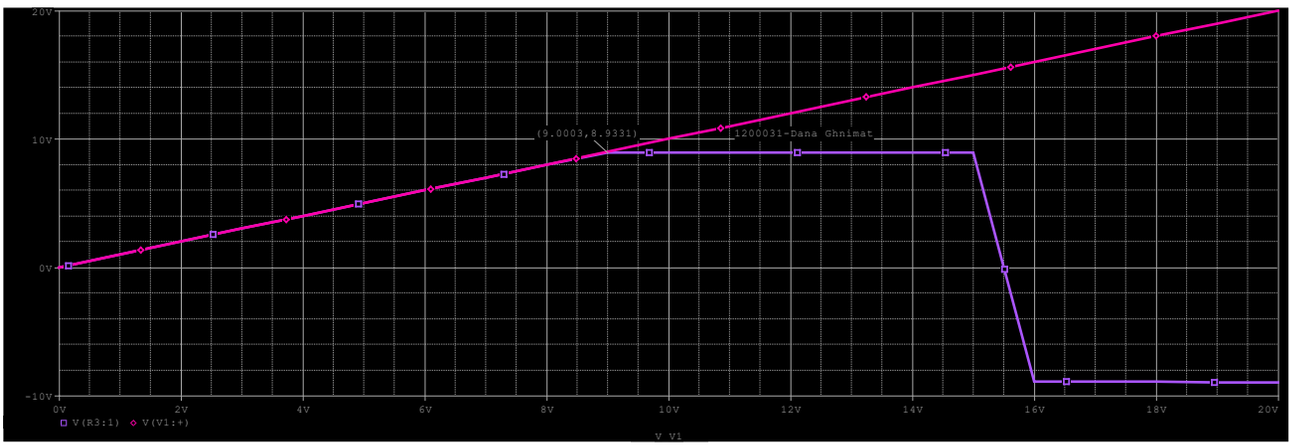

Figure 4 input and output voltage and the saturation mode

Vo = Vi from 0 to around 9
Vo = 8.9331 for [9 -15]
Vo = -8.9331 for [15 -20]

Output Current when R3 = 220Ω:

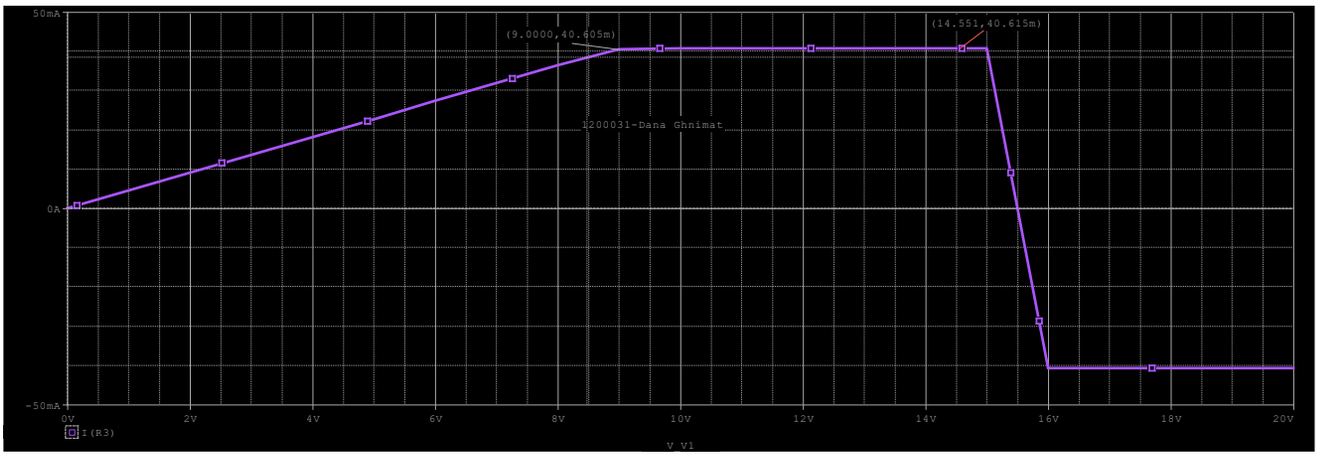

Figure 5 input Current and the saturation mode current

From Figure 5 from 0 to around 9, Io is increasing linearly until it reaches 40.605mA, from 9 to 15, Io at saturation mode which equals to 40.615mA.

Io and Vo have the same characteristics. That means that Voltage follower and the current follower, which shows a unity gain maintaining a nearly one-to-one relationship between input and output voltages, as operational amplifier (op-amp) buffering voltage standard amp.

Output Voltage when R3 = 1kΩ:

After R3 has been changed to 1kΩ.

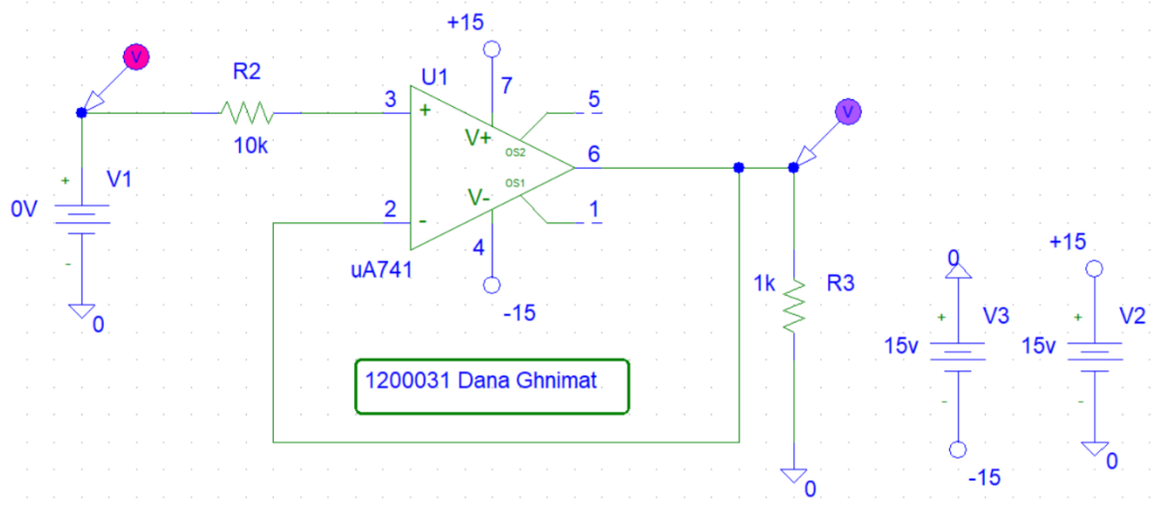

Figure 6 Voltage Follower Application when RL = 1kΩ

Simulation and saturation mode:

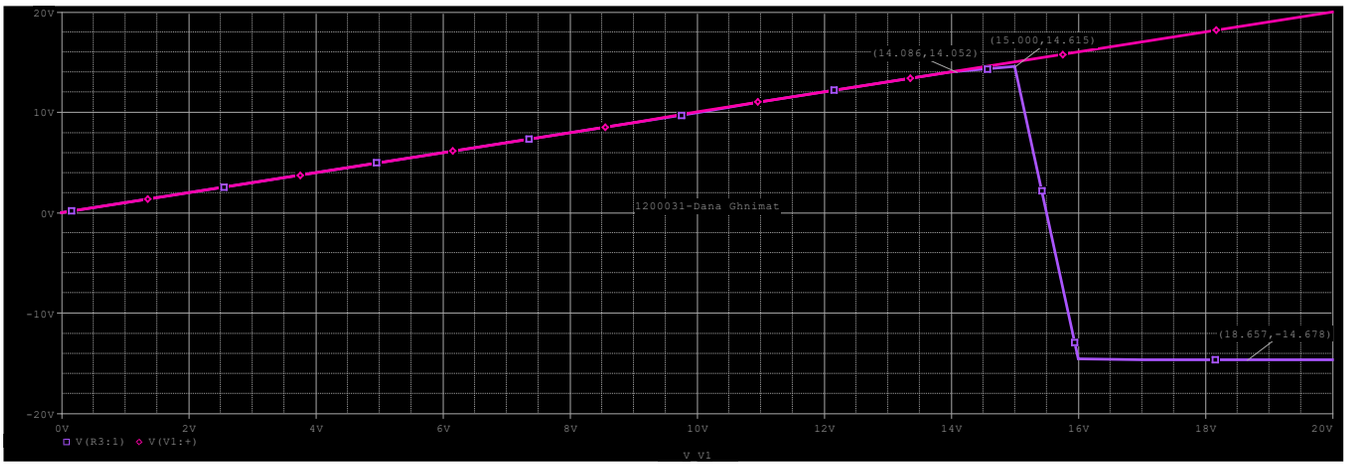

Figure 7 Saturation Mode Output Voltage

From Figure 7:

Vo = Vi from 0 to around 14 (14.086)
Vo=Vmax = 14.615 for [14.086-15]
Vo = -14.678 for [15 -20]

Output Current when R3 = 1kΩ

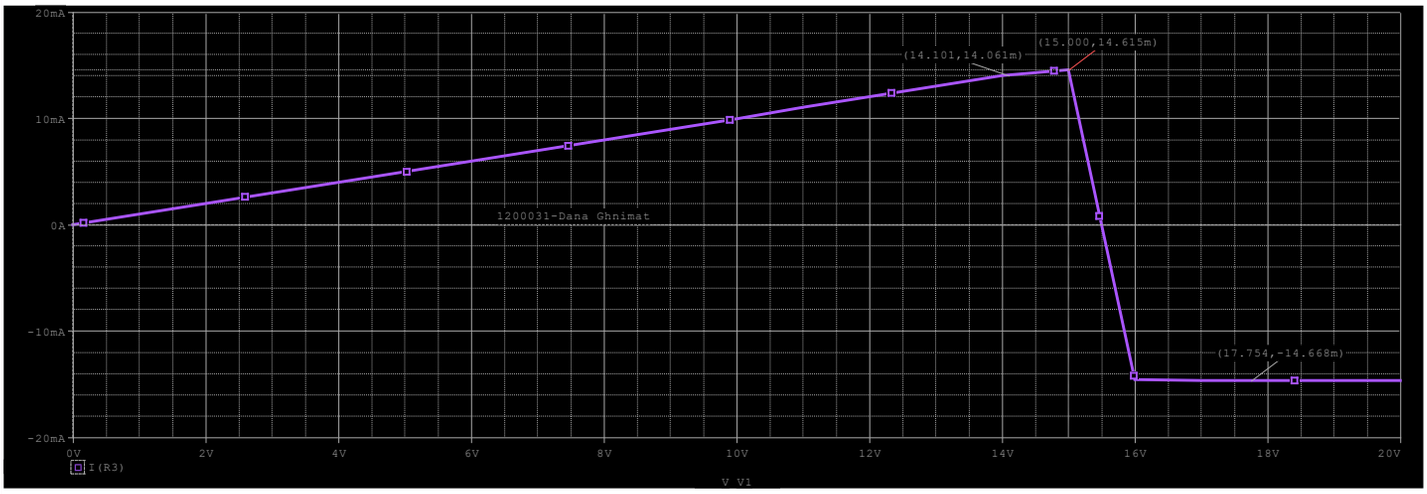

Figure 8 Output Current and Saturation Mode

From Figure 8 noted that from [0 - ~14], Io is increasing then stop from]14 -15], Io at saturation mode equals 14.615mA.

Io and Vo have the same characteristics. this indicates that Voltage follower and the current follower, shows a voltage gain close to unity, maintaining a nearly one-to-one relationship between input and output voltages.

Part 3: Comparator Application

The circuit of the comparator has been sat up as the following:

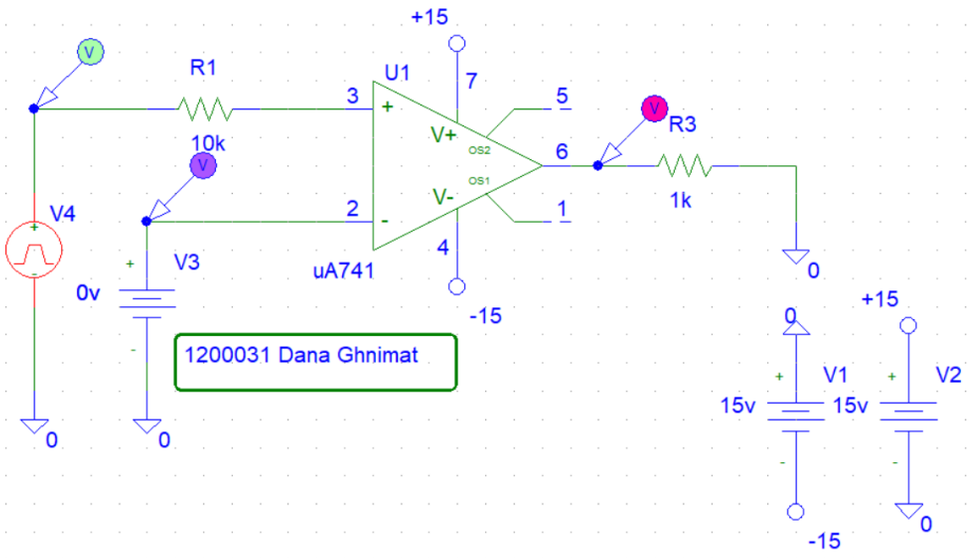

Figure 9 voltage comparator.

Vpulse values are: AC =0, DC = 0,

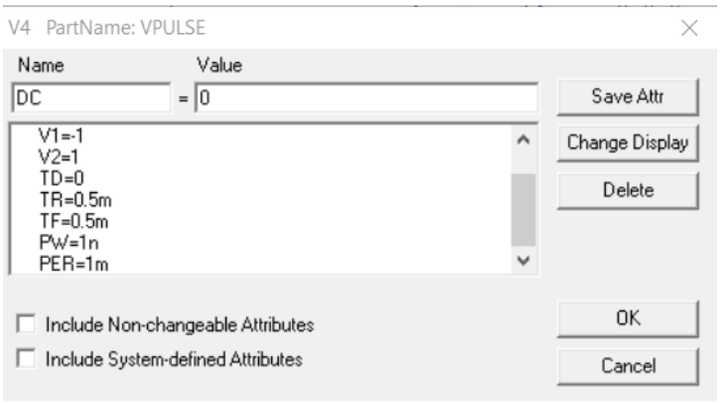

Figure 10 Vpulse values.

Simulation when V3 =0v.

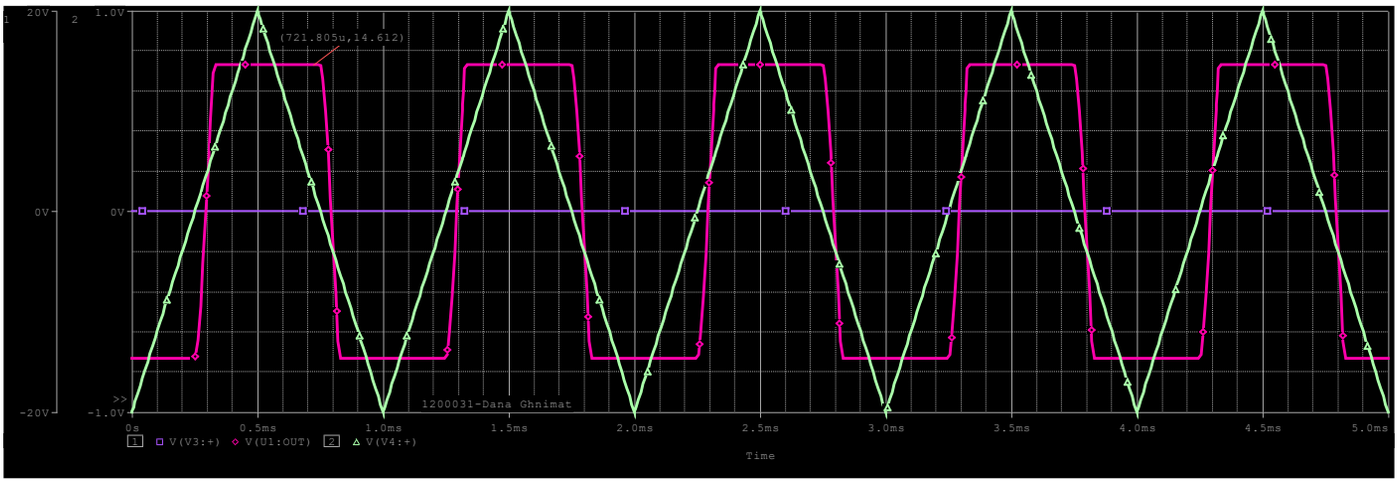

Figure 11 VO & Vin & V4 when V3=0V.

V3 = -1.5V

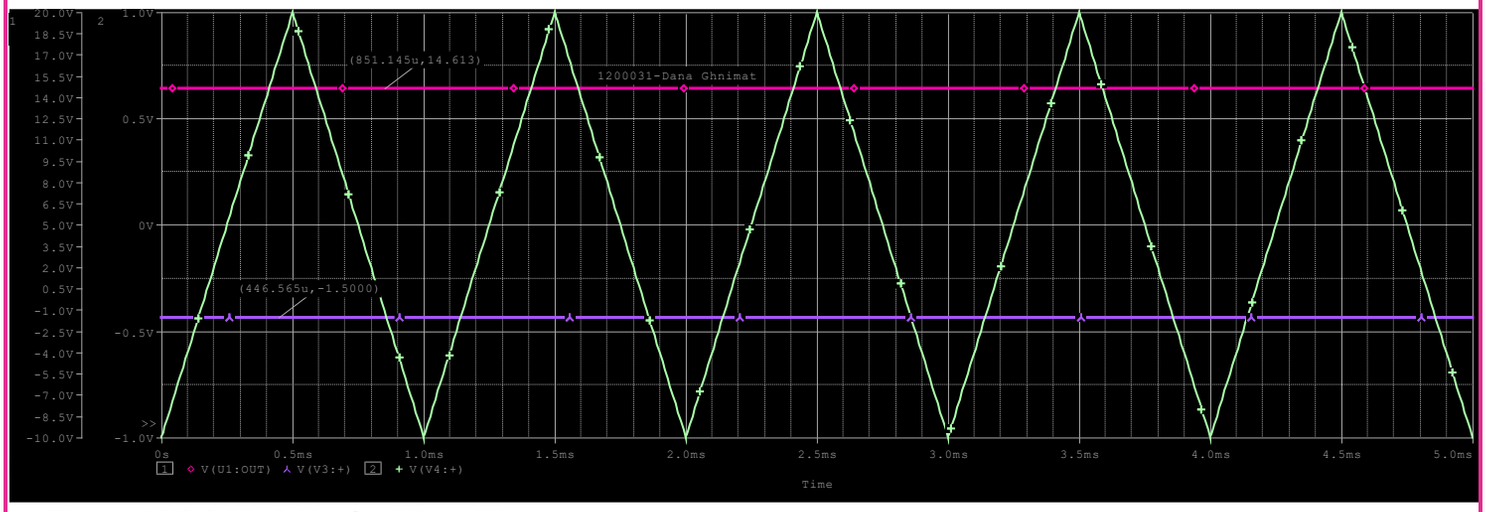

Figure 12 VO & Vin & V4 when V3=-1.5V.

Figure 12 shows the input and output voltage as -Vsat wave. with the potentiometer of 10k value and reverse the voltage on it.

V3 = -1V

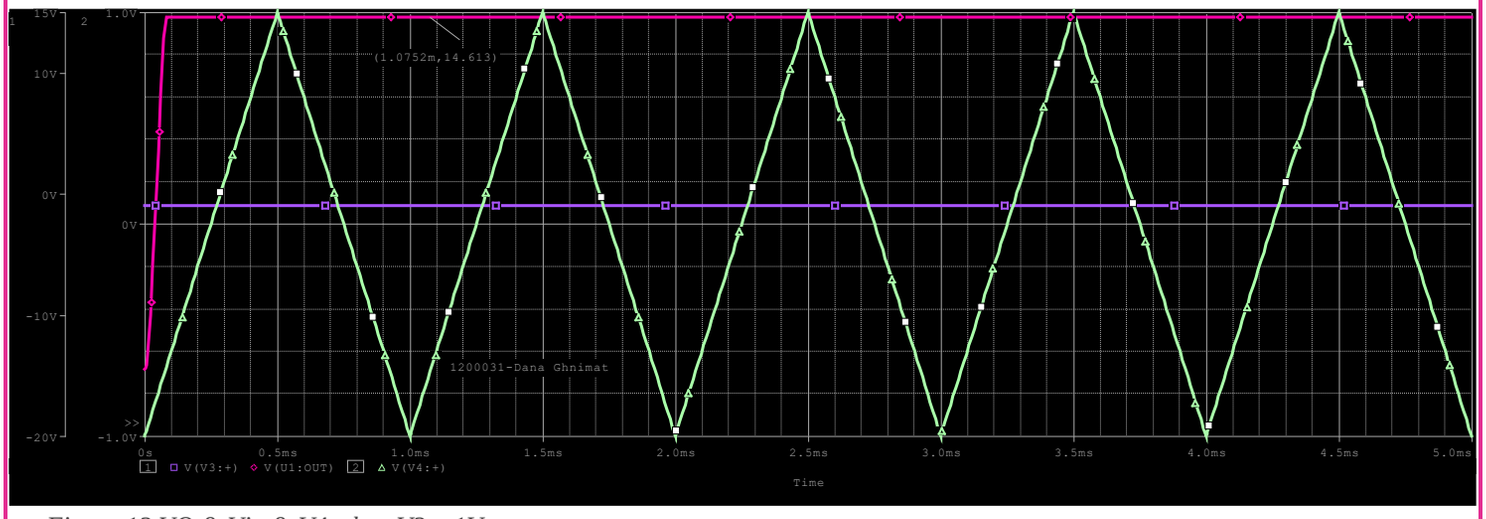

Figure 13 VO & Vin & V4 when V3=-1V.

V3 = 1V

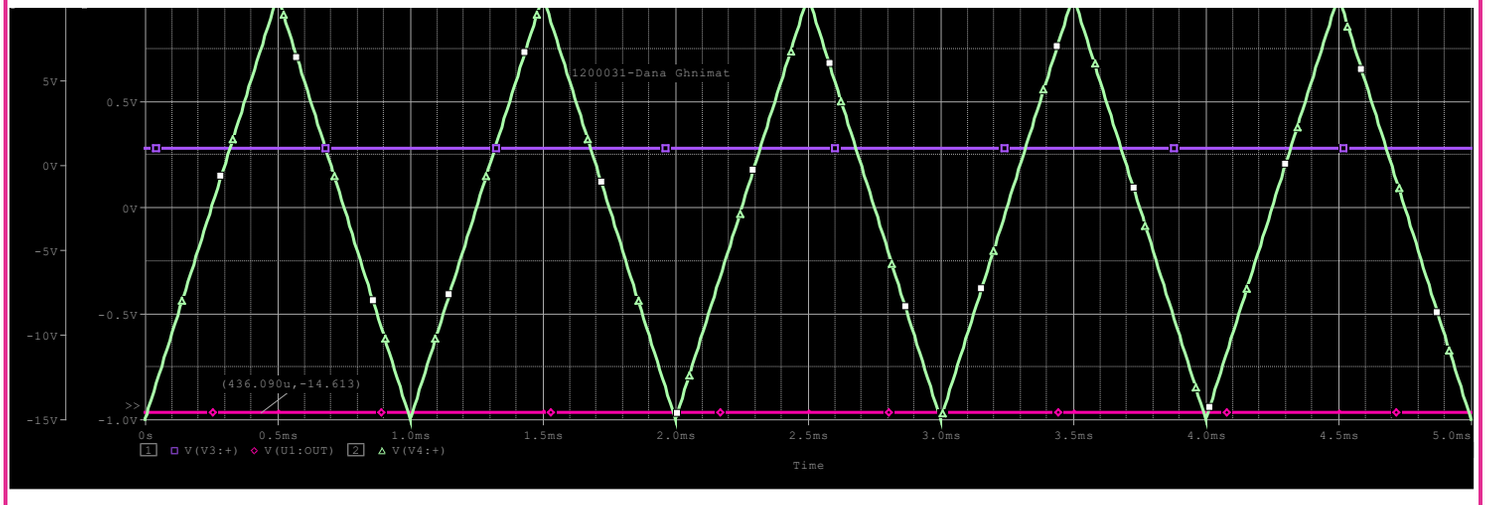

Figure 14 VO & Vin & V4 when V3=1V.

V3 = 1.5V

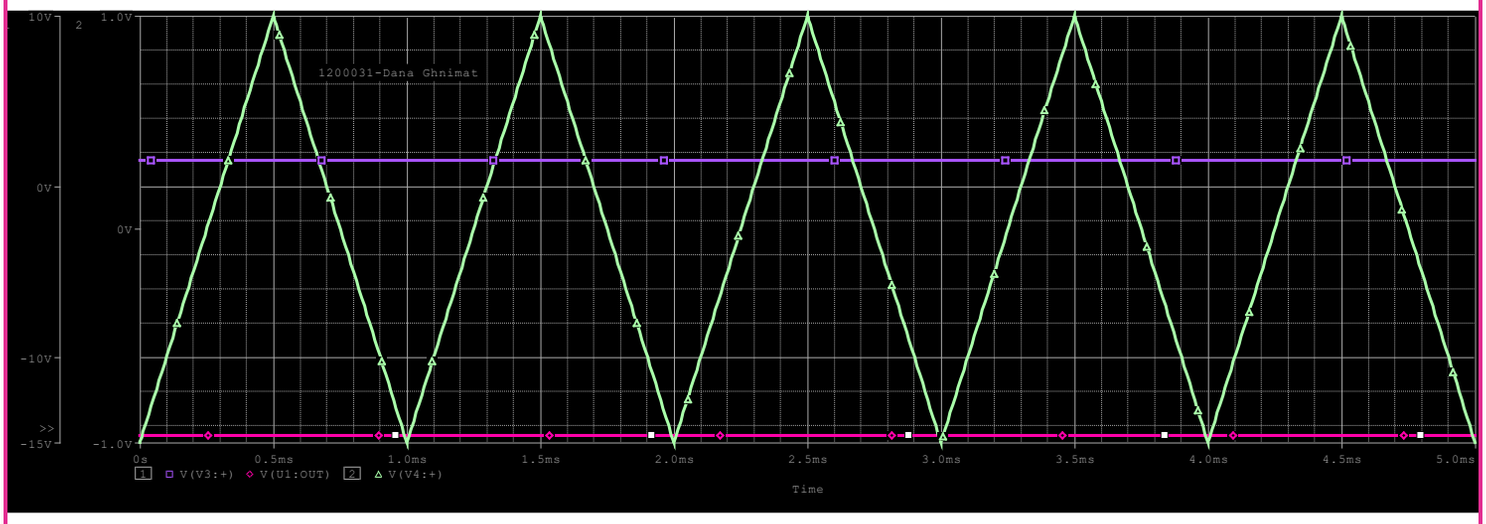

Figure 15 VO & Vin & V4 when V3=1.5V.

Figure 15 shows the input and output voltage as +Vsat wave.

Conclusion: In Opamp comparator

V (+) > V (-) => Vo = +Vsat
V (+) < V (-) => Vo = -Vsat

Part4: Comparator with Hysteresis (Schmitt Trigger)

Figure 16 shows comparator with Hysteresis circuit with input voltage have 15VPP and 1 kHz frequency

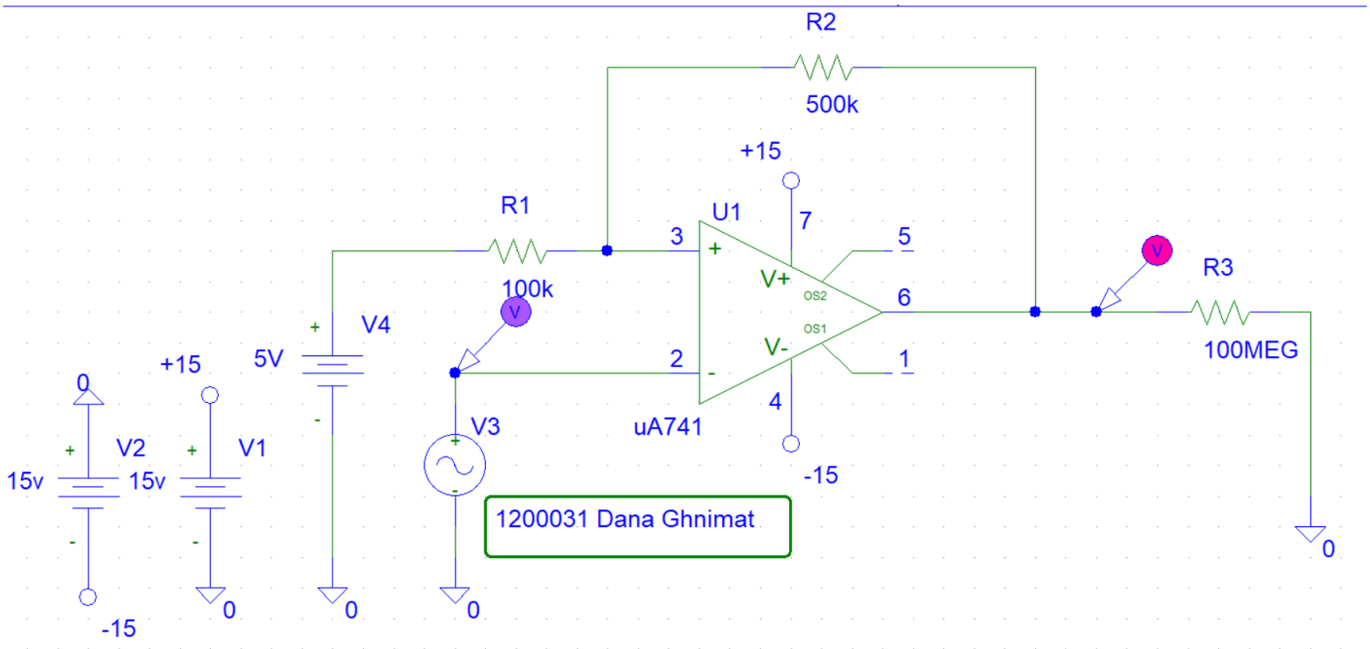

Figure 16 Comparator with Hysteresis (Schmitt Trigger)

Vsin parameters:

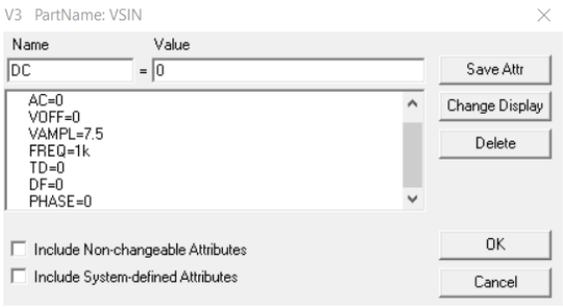

Figure 17 Vsin parameters

Simulation:

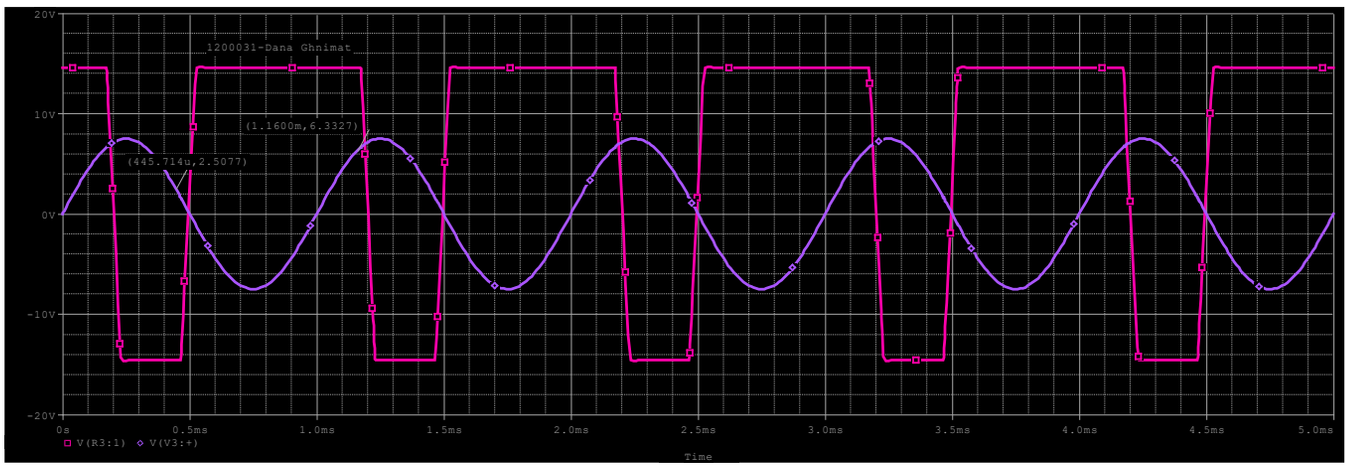

Figure 18 Comparator with Hysteresis (Schmitt Trigger) simulation calculated values

Simulation with practical values:

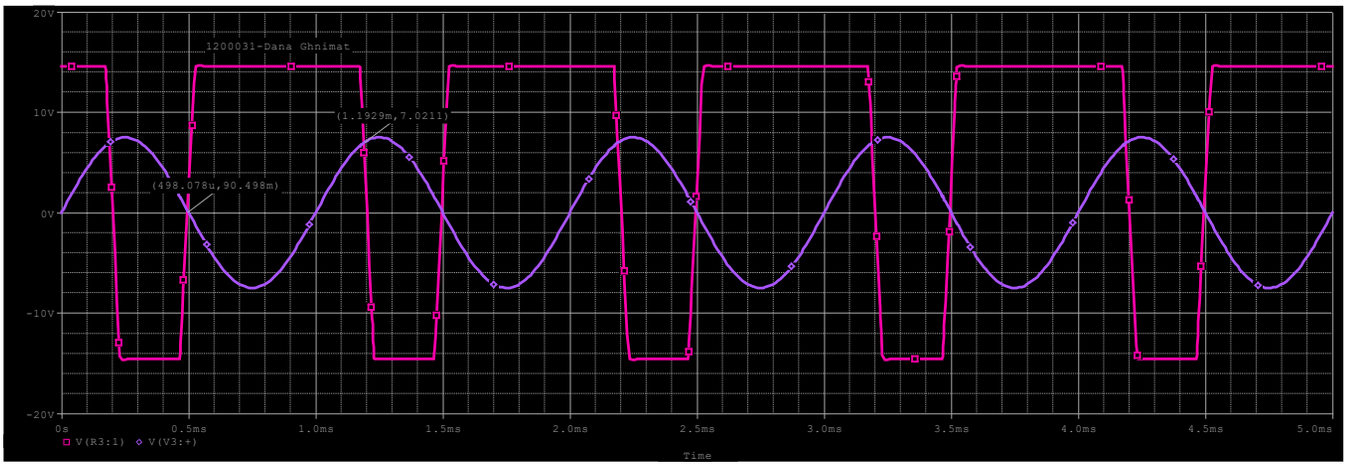

Figure 19 Comparator with Hysteresis (Schmitt Trigger) simulation

Practical values for V_{UT} = 7.0211V, V_{LT} = 0.09076mV

Mean while in calculations:

Note that $+V_{SAT} = V_{CC} - 2 = 15 - 2 = 13$

and $-V_{SAT} = -V_{CC} + 2 = -15 + 2 = -13$.

the upper threshold and lower threshold can calculate as:

$$V_{UT} = \left(\frac{R_1}{R_1+R_2} V_{sat} + \frac{R_2}{R_1+R_2} (5)\right)$$

$$\left(\frac{100k}{600k} 13 + \frac{500k}{600k} 5\right)$$

$$= 6.333$$

$$V_{LT} = -\left(\frac{R_1}{R_1+R_2} V_{sat}\right) + \frac{R_2}{R_1+R_2} (5)$$

$$-\left(\frac{100k}{600k} 13\right) + \frac{500k}{600k} 5$$

$$= 2$$

Then the Hysteresis voltage can be given as:

$$V_H = V_{UT} - V_{LT}$$
$$= 6.3333 - 2$$
$$= 4.333$$

When the voltage at one of a device's inputs changes, two additional voltage values are created to act as reference points.

The Lower Threshold Point is the lowest change point, while the Upper Threshold

Point is higher change point.

Hysteresis voltage is the name for the subtraction between these two values.