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Pspice_Project

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I pledge my honor that I have neither given nor received any unauthorized aid on this assignment.

Description of the Project:

In the project, implementation of the circuit (which is shown in Figure 1) in Pspice, and interpretation of the results in different situations:

- whether the ideal opamps (Figure 2) are used or TL072 opamps [1] are used while varying the input voltage ((SIG+) - (SIG-)) from -5V to 5V, (part_a, part_b1)
- the resistors have a rate of 25% tolerance, when the input voltage is 1.2V, (part_b2)
- the input voltage is a 1.5V peak-to-peak sine wave at 1 kHz. (part_b3)

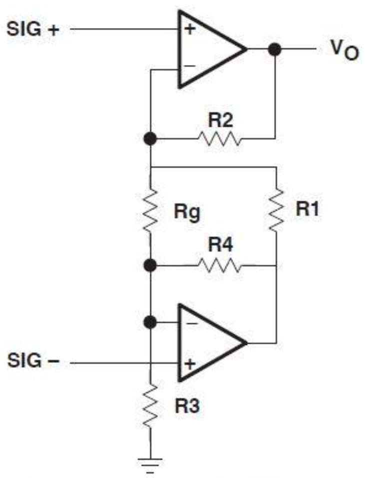

Figure 1 - R1=R2=2k, R3=R4=1k, Rg=1k

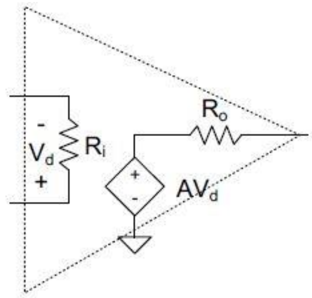

Figure 2- Ri=150kΩ, Ro=250Ω, A=5500

Implementations of The Circuit

Part A:

In this part, the implementation of the circuit containing the opamp in the Figure 2 while varying the input voltage from -5V to 5V is asked. The schematic of the circuit is given by the Figure 3. To analyze the output voltage result, the analysis type of dc sweep should be determined. The setting of the analysis is given by Figure 4. After doing this analysis, the result outputs are given by Figure 5.

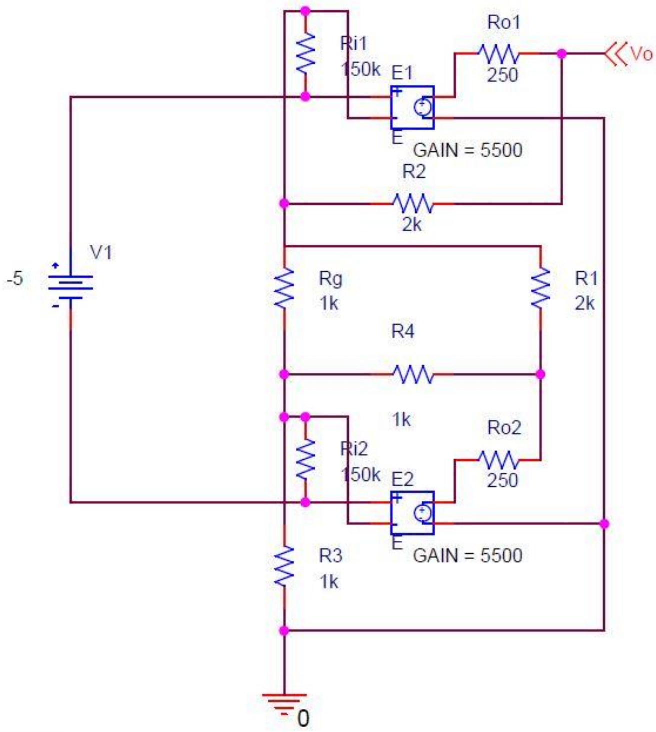

Figure 3: The schematic of the circuit

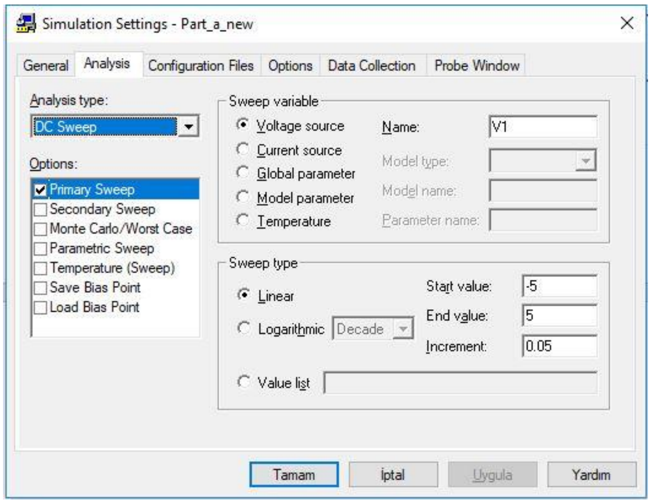

Figure 4: The setting of the analysis

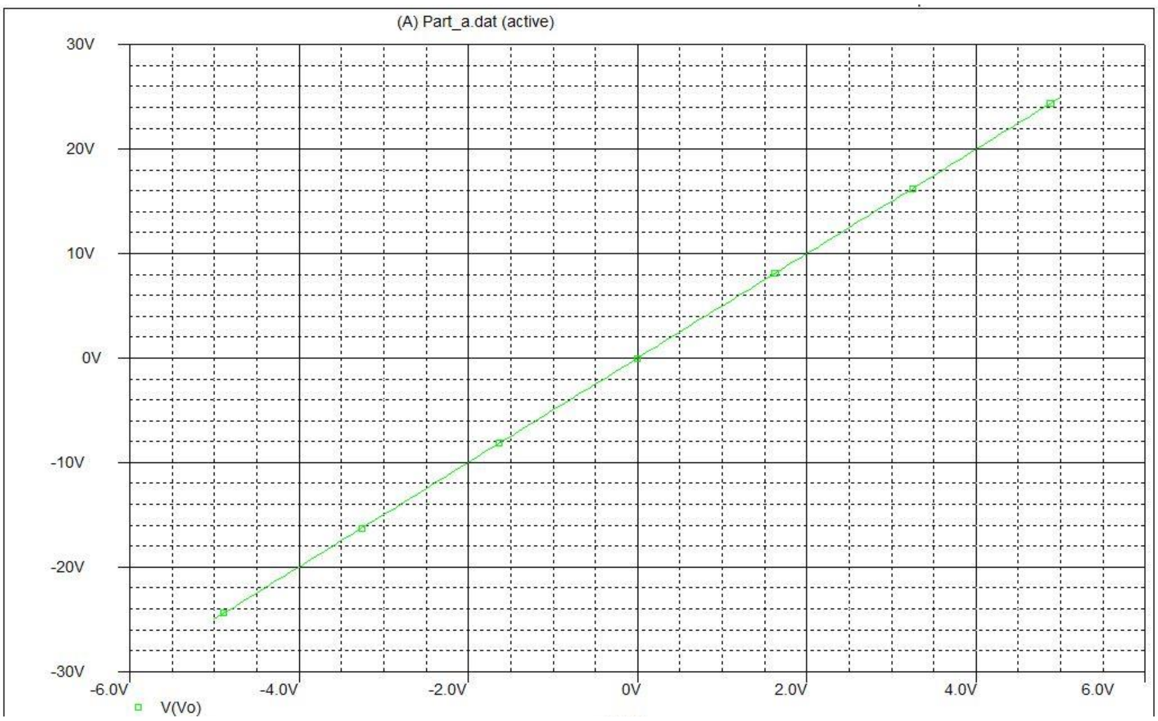

Figure 5: The result outputs

The input-output voltage relation is as it is expected, namely the circuit does amplify the input voltage value by 5 times and the relation is linear.

Part B:

1. In this section, the implementation of the circuit containing the TL072 opamp[1] with the power supply voltages -10V/10V while varying the input voltage from -5V to 5V is asked. The schematic of the circuit is given by the Figure 6. To analyze the output voltage result, the analysis type of dc sweep should be determined. The setting of the analysis is given by Figure 4 (the same setting of the part a). After doing this analysis, the result outputs are given by Figure 7.

[1] The addition of the TL072 opamp to the library of Pspice is done as in the lecture.

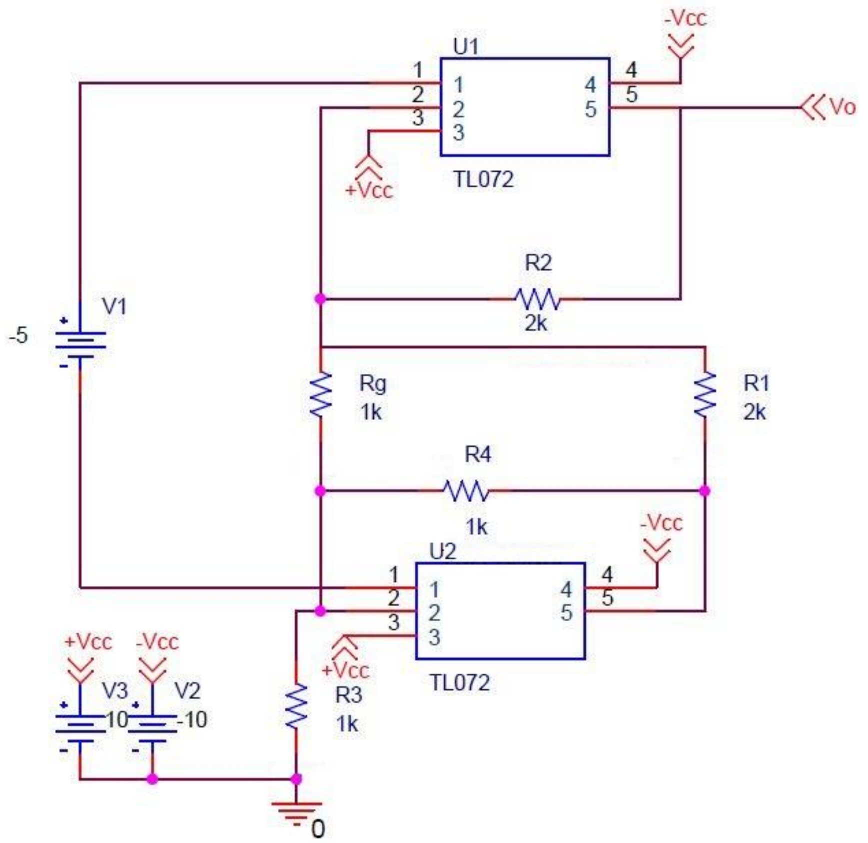

Figure 6: The schematic of the circuit

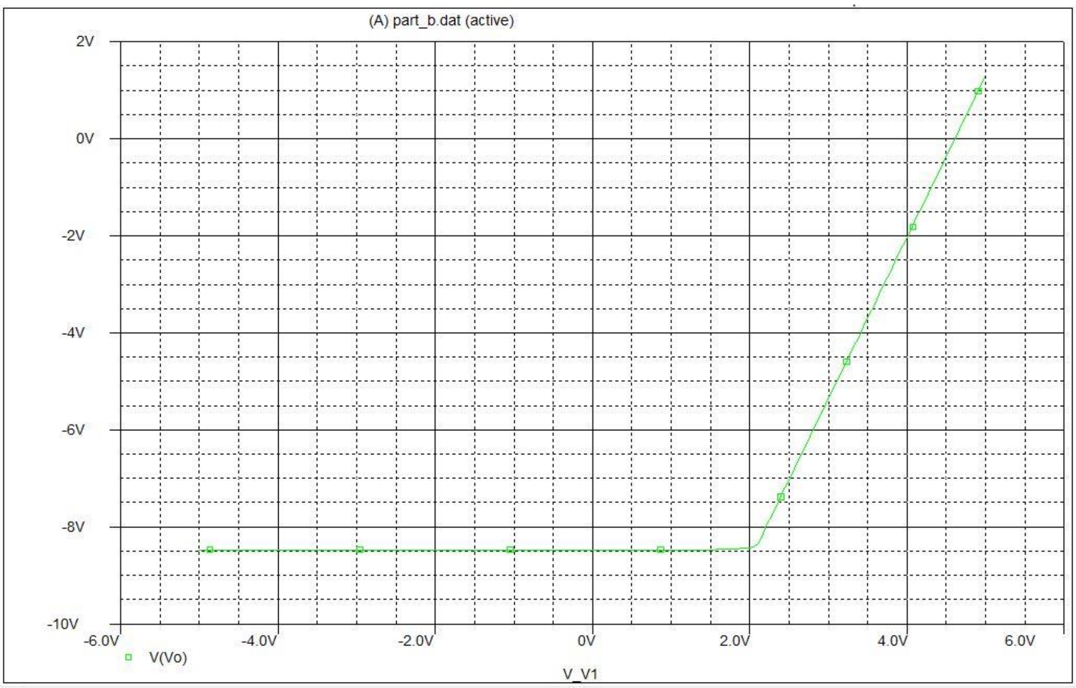

Figure 7: The result outputs

The result outputs are not as it is expected, because it doesn't satisfy the formula [2] that relates the input voltage and the output result. The reason why it doesn't satisfy this formula is that "Normally full-scale output voltages are in the 10 mV to 100 mV range." [3]. Namely, opamps in the circuit don't in the linear region, they work as they are in the saturation region, so the circuit analysis ends up with unexpected results. And the output voltage can only come down -8.5V, but in ideal case it should be -10V. The probable reason for that is the non-ideality of the TL072 opamps.

In the part a, the analysis ends up with expected results, because the opamps used in the circuit are ideal and they don't saturate in any voltage inputs, however in the part b1, the analysis results aren't expected because the opamps used the circuit aren't ideal and they saturate in a region which determined by the supply voltages.

2. In this section, determination of the range of the output voltage at Vin=1.2V if the resistors have the rate of 25% tolerance. To add such a property to the resistors, the edition procedure[2] of a property should be done. To analyze the circuit behavior under the condition that the 25% tolerance resistors are used, dc sweep analysis with monte carlo/worst case option should be taken, the setting of the analysis is given by Figure 8. The result of the analysis is given by Figure 9.

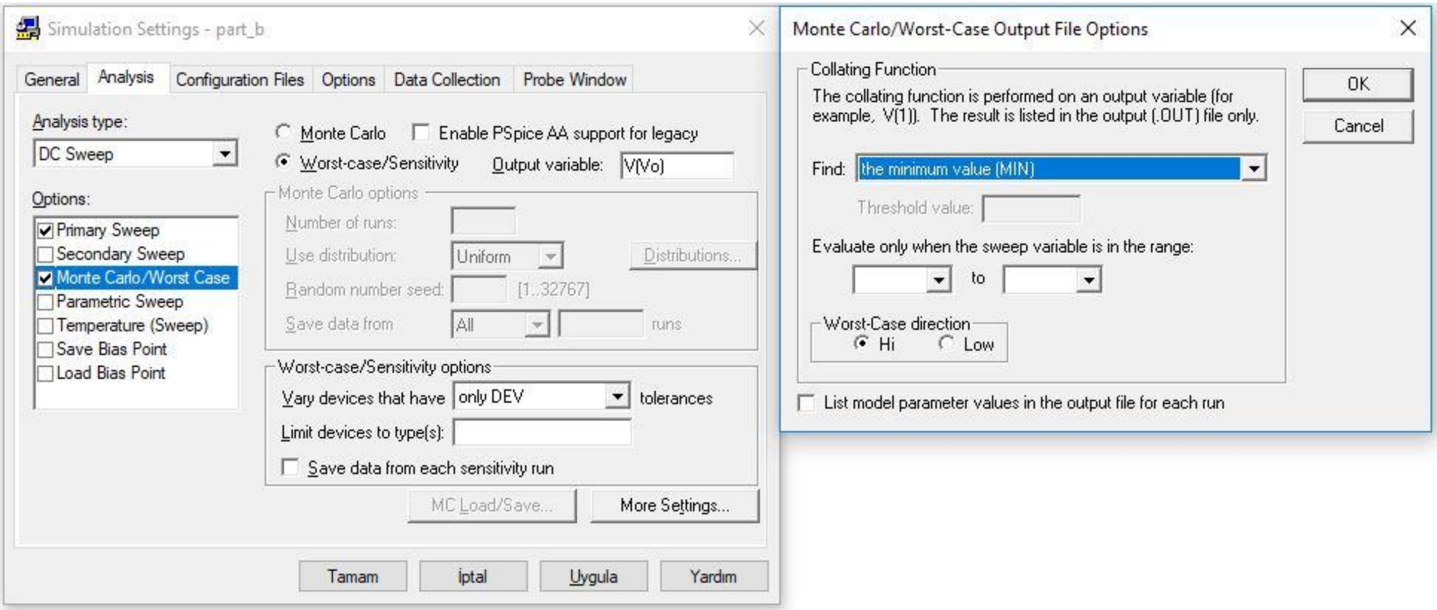

Figure 8: The setting of the analysis

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RUN                        MINIMUM VALUE

WORST CASE ALL DEVICES
                           -8.4776 at V_V1 =     1.2
                            ( 100   % of Nominal)
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Figure 9: The result of the analysis

[2] The edition procedure is done as in the lecture.

The range of the output voltage is again unexpected; the worst-case analysis concludes that the output voltage doesn't depend on the resistors tolerance. The probable reason for that can be that the given voltages into the opamps aren't defined, only the voltage difference of the input is defined[3], namely the both opamps may saturate in the given voltage, so the output voltage doesn't depend on the resistors, because it is determined by only the voltage supplied to the opamps.

3. In this section, determination of the output when Vin is a 1.5V peak-to-peak sine wave at 1 kHz is asked. To this analysis, the time domain analysis type should be taken. The setting of the analysis is given by Figure 10. The result of the analysis is given by Figure 11.

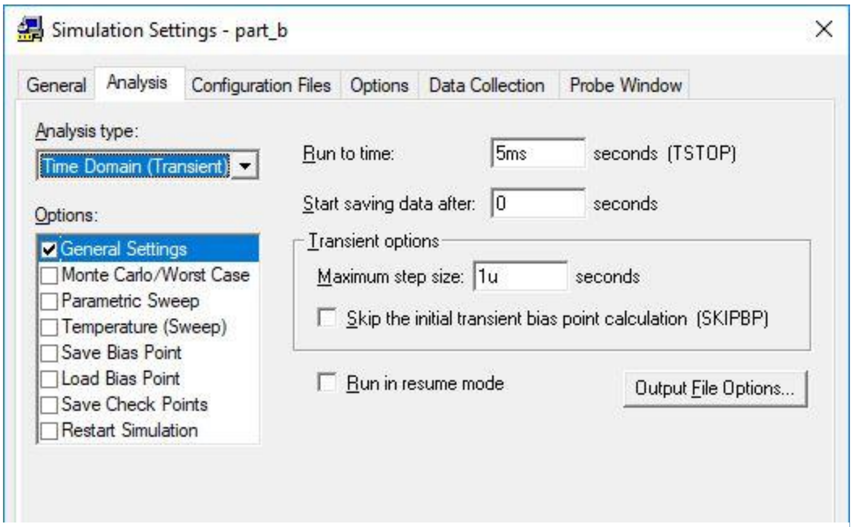

Figure 10: The setting of the analysis

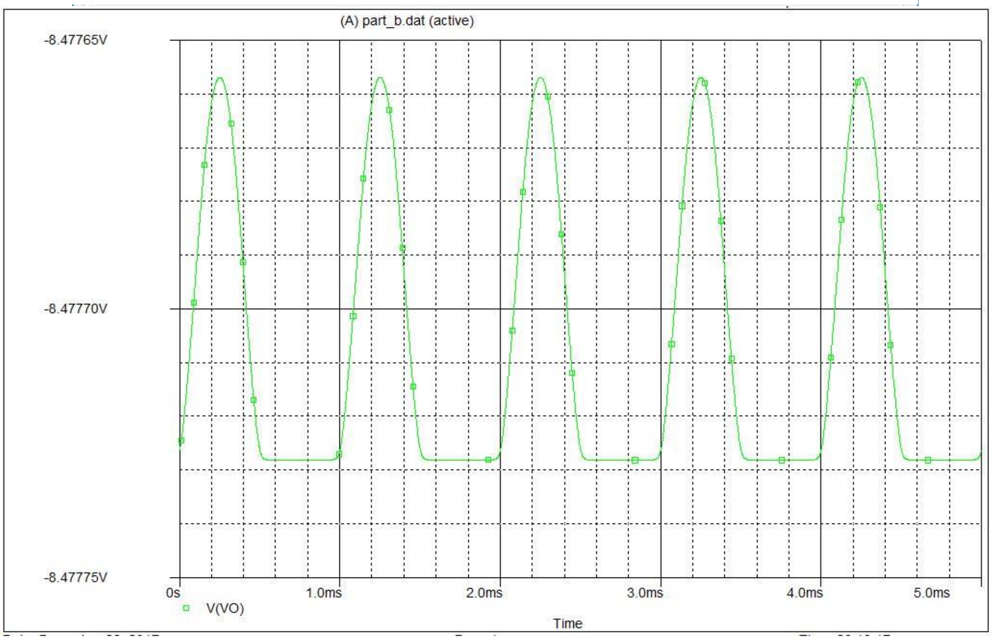

Figure 11: The result outputs

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[3] Further observation is made in the end.

The output voltage is a saturated from below sine wave that oscillates from -8.47773V to -8.47764V. Again, this result is unexpected, because the expected result is an amplified sine wave namely, the amplitude of the sine wave would have been greater than 1.5V however it is about 0.00011V, because the opamps aren't in the linear region.

Some Observations about The Unexpected Results

I think, the probable reason for unexpected results is that the output voltage does not only depend on Vin (the difference of the SIG+ and SIG-), it depends on the actual value of the SIG+ and SIG- when the opamps are not in the linear region. In the project, I didn't connect ground to the Vin as the project instruction says (it doesn't restrict the actual value of the SIG+ and SIG-, it gives info only about the difference of them.). Namely, I didn't set any restriction about the actual value of the SIG+ and SIG-, then the source connected in the circuit set a value relatively with the ground in R3 to these inputs and these values cause saturations of the opamps because they are too large [4] for the opamps to work in the linear region. However, if we set SIG- to 0 via connecting ground, then both inputs are set to actual values that defined by the connected source. And doing this change, the results are more expected than previous ones. The results are given by Figure 12, 13, 14.

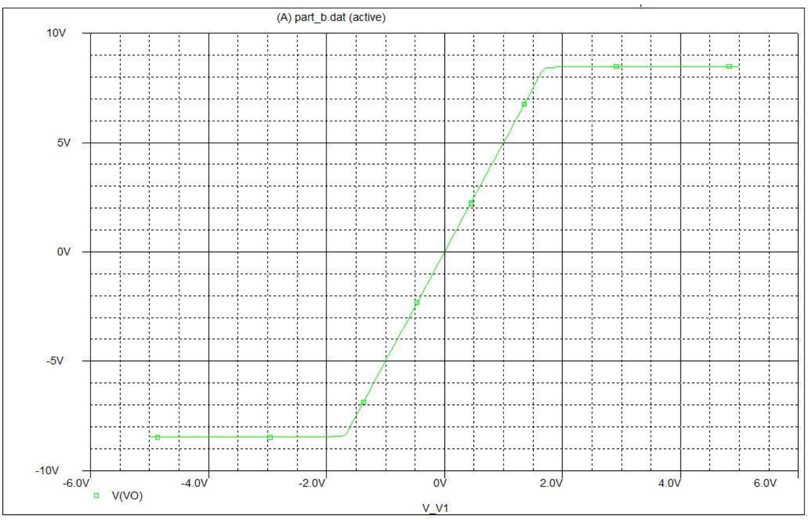

Figure 12: Vo from part b1

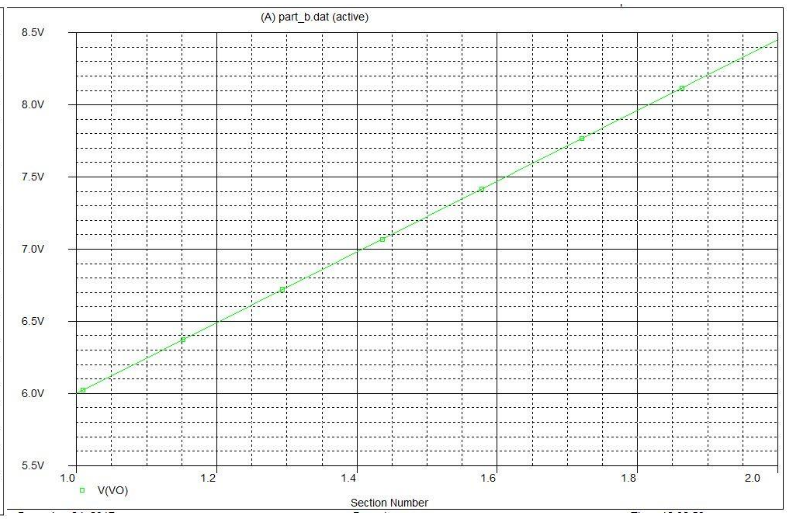

Figure 13: The range of Vo from part b2

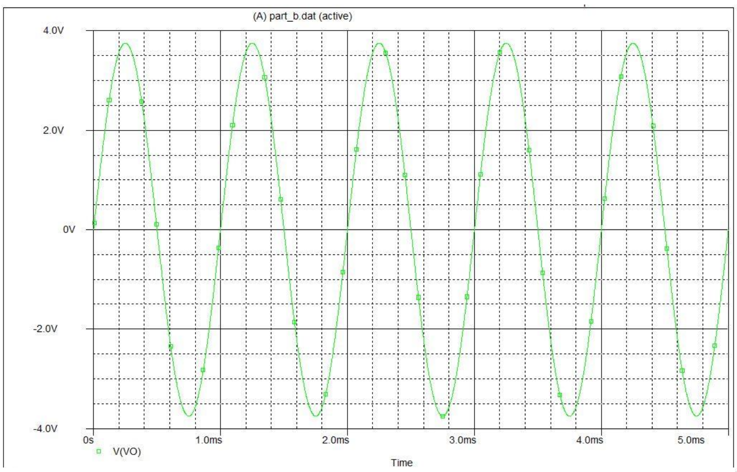

Figure 14: Vo from part b3

These results are what we expect the circuit, namely

- for part b1, we expect that opapms are in the linear region when Vin is in between -2 and 2, and ideally amplify Vin by 5 times (however, the opamps aren't ideal so they cannot amplify this much.),
- for part b2, we expect that Vo varies as the resistors have some tolerance values, when we define tolerance 25% for each resistor, the range of the output voltage is given by Figure 13, and in the worst case it has 140% nominal value at Vin=1.2V,
- for part b3, we expect that Vo is an amplified version of the input voltage namely an amplified sine wave with a larger amplitude than Vin, and it can be observed when we connect ground to SIG-.

Reference:

[1] http://focus.ti.com/docs/prod/folders/print/tl072.html

[2] Section 2.3, J. Karki, "Signal Conditioning Wheatstone Resistive Bridge Sensors."

[3] Section 2, J. Karki, "Signal Conditioning Wheatstone Resistive Bridge Sensors."

[4] Section 2, J. Karki, "Signal Conditioning Wheatstone Resistive Bridge Sensors."