Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Title:	ELE302 Electric Networks
Course Number:	ELE302
Semester/Year (e.g.F2016)	F2024

Instructor:	S. Jassar

Assignment/Lab Number:	1
Assignment/Lab Title:	Operational Amplifier Circuit Configuration

Submission Date:	Fri 20, 2024 9pm
Due Date:	Fri 20 2024, 9pm Part I (1-5), part II (7-11)

Student LAST Name	Student FIRST Name	Student Number	Section	Signature*
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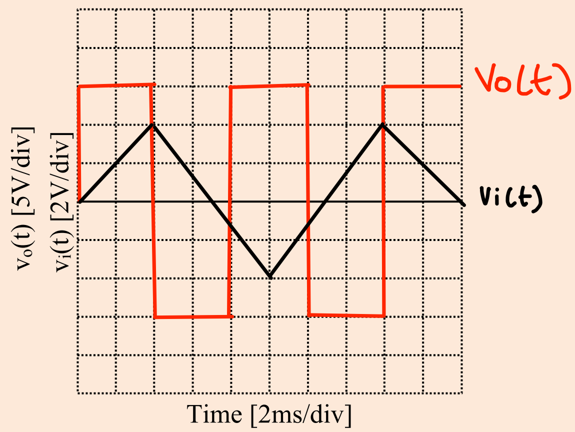
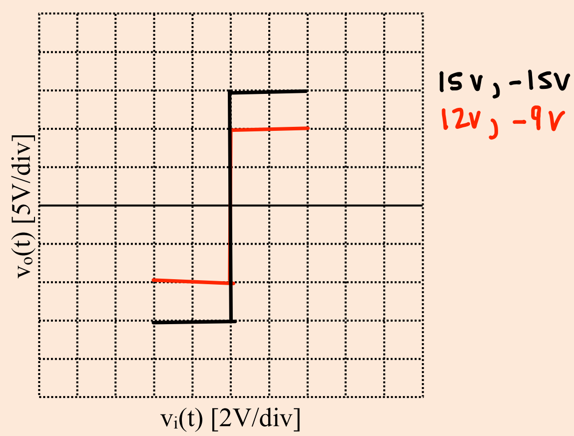
*By signing above you attest that you have contributed to this written lab report and confirm that all work you have contributed to this lab report is your own work. Any suspicion of copying or plagiarism in this work will result in an investigation of Academic Misconduct and may result in a "0" on the work, an "F" in the course, or possibly more severe penalties, as well as a Disciplinary Notice on your academic record under the Student Code of Academic Conduct, which can be found online at: http://www.ryerson.ca/senate/current/pol60.pdf



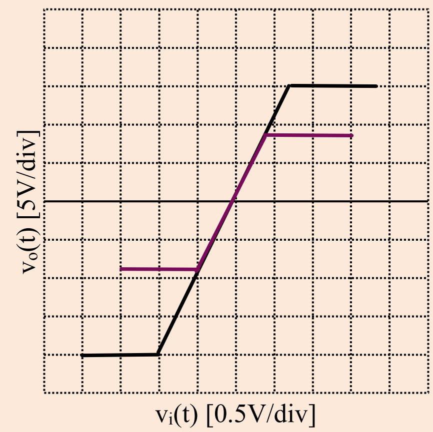
Graph 2.0 (0.5 marks)



Graph 3.0 (0.5 marks)

(e) Step 5: Change the values of both the positive & negative dc-supply voltages to +15V and -15V, respective, and modify your circuit as shown in **Figure 3.0**. Negative feedback is now said to be applied around the Op-Amp, with feedback factor $\beta = R_1/(R_1 + R_2)$, and the circuit is said to operate as a non-inverting amplifier. Plot the resulting voltage-transfer characteristics on **Graph 4.0**. Record feedback factor β in **Table 1.0**. Use your graph to record the Dynamic Range and Voltage Gain also in **Table 1.0**. (The **Dynamic Range** is the linear region of the voltage-transfer characteristics**.)**

(f) Step 6: This concludes the first 3-hr lab session. Please demonstrate Step 1 to Step 5 to your TA and submit your answers to the prelab assignments and the results collected from Step 1 to Step 5 to your TA at the end of the lab session. (1 mark)



Graph 4.0 (0.5 marks)

$\frac{1}{11} = 0.091$

$\frac{10}{57} = 0.175$

Table 1.0 (0.5 marks)

Circuit Conditions	Feedback Factor β	Valid Input Range (Dynamic Range) for $v_i(t)$	Voltage Gain $[v_o(t)/v_i(t)]$
Negative feedback [R_1=10kΩ & R_2=100kΩ]	0.091	7.96	14.05/4 = 3.51
Negative feedback [R_1= 10kΩ & R_2=47kΩ]	0.175	7.87	14.24/3.91
Negative feedback [R_1=inf & R_2=0]	$\frac{\infty}{\infty+10} = 1.0$	8.01	3.8/3.84

(g) Step 7: Replace R_2 with a 47kΩ resistor on the **Figure 3.0** circuit. Use **Graph 4.0** to plot the resulting XY-mode voltage transfer curve. Use your plot to fill-in **Table 1.0**.

(h) Step 8: By replacing the resistor R_1 with an open-circuit and the resistor R_2 with a short-circuit, your circuit is now said to operate as a voltage follower. Use **Graph 4.0** to plot the resulting voltage-transfer curve, and fill-in the blanks in **Table 1.0**.

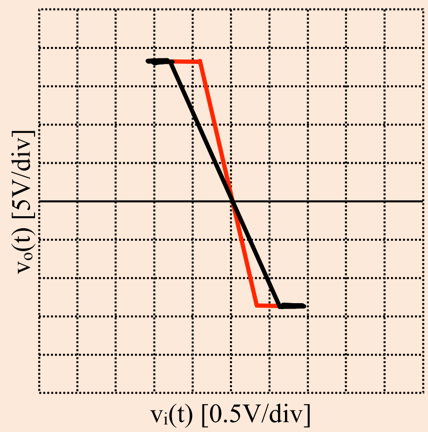
(i) Step 9: Modify your circuit as shown in **Figure 4.0**. The circuit is now said to operate as an inverting amplifier. Use **Graph 5.0** to plot the resulting voltage-transfer characteristics and fill-in the blanks in **Table 2.0**.

(j) Step 10: Replace R_2 with a 47kΩ resistor. Use **Graph 5.0** to plot the resulting voltage transfer curve. Use your plot to fill-in the blanks in **Table 2.0**.

(k) Step 11: Demonstrate Step 7 to Step 10 to your TA. (1 mark)

100k

47K



Graph 5.0 (0.5 marks)

Table 2.0 (0.5 marks)

Circuit Conditions	Feedback Factor β	Valid Input Range (Dynamic Range) for $v_i(t)$	Voltage Gain [$v_o(t)/v_i(t)$]
Negative feedback [R_1=10kΩ & R_2=100kΩ]	1/11	2.9	14 / -3.92
Negative feedback [R_1= 10kΩ & R_2=47kΩ]	10/57	5.4	14.64 /-4.02

6.0 POST-LAB QUESTIONS (2 marks in total, 0.5 marks for each question):

(1) By examining your plots on **Graph 3.0**, answer the following:

a) What are the effects of the dc-supply voltages on the voltage-transfer characteristics?

b) Would the solo Op-amp qualify as a practical amplifier circuit? Comment on your answer.

a) Basically looking at the graph 3.0 we can see that the voltages effect the amplitude.
For example, the ±15 has a greater amplitude compared to the 12V and 9V.

b) Yes the solo op-amp does qualify as a practical amplifier circuit.

(2) By considering your plots on **Graphs 3.0, 4.0 & 5.0**, answer the following:

a) What does the application of negative feedback (around the Op-amp) have on the amplifier-circuit behavior?

b) Does the application of negative feedback have any effect on the output saturation voltages? Comment on your answer.

a) Looking at the graph 3.0, what can be seen is that the slope is perpendicular to the X-axis. However, the slope for graph 4.0 and graph 5.0 is linear. For graph 3.0 there is no negative feedback so this can result into a perpendicular slope. However For the graph 4.0 and 5.0 there is negative feedback which results into a linear slope

b) It doesn't look like negative feedback has any effect on the output voltage saturation.

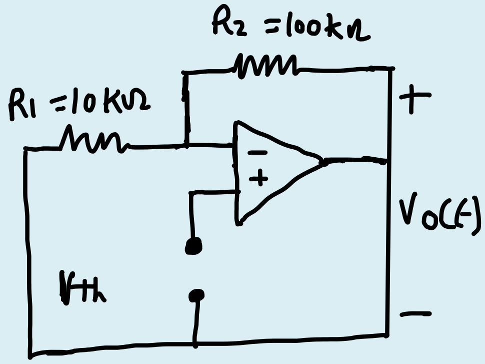
(3) Thevenin Equivalent Input Resistance:

a) Calculate the Thevenin equivalent resistance seen by $v_i(t)$ for the non-inverting configuration shown in **Figure 3.0**.

b) Calculate the Thevenin equivalent resistance seen by $v_i(t)$ for the inverting configuration shown in **Figure 4.0**.

c) Which configuration has higher Thevenin equivalent resistance as seen by $v_i(t)$?

a)



$$V_{th} = V_0 \frac{R_1}{R_1+R_2} - v_{in}\frac{R_1}{R_1+R_2} + V_{in}$$

$$V_{th} = \frac{10}{10+100}V_o - \frac{10}{10+100}v_i + V_i$$

$$v_{th} = \frac{1}{11}V_0 + \frac{10}{11}V_i$$

$$V_{th} = \frac{1}{11}(27.94) + \frac{10}{11}(2.5)$$

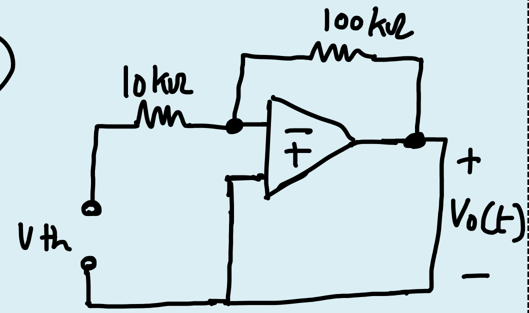
$$V_{th} = 4.81V$$

$$R_{th} = \frac{V_{th}}{V_i}$$

$$= \frac{4.81}{2.5}(10000) \rightarrow = 19240\Omega$$

$$R_{th} = 19240\Omega$$

b)



$$\frac{0-V_0}{100} + \frac{0-V_{th}}{10} = 0$$

$$\frac{V_{th}}{10} = \frac{V_0}{100}$$

$$V_{th} = \left(\frac{27.94}{100}\right)10$$

$$V_{th} = 2.794$$

$$R_{th} = \frac{V_{th}}{v_i}$$

$$R_{th} = \frac{2.794}{2.5}(10000)$$

$$R_{th} = 11176\Omega$$

c) ∴ The non inverting has a higher resistance equivalence.

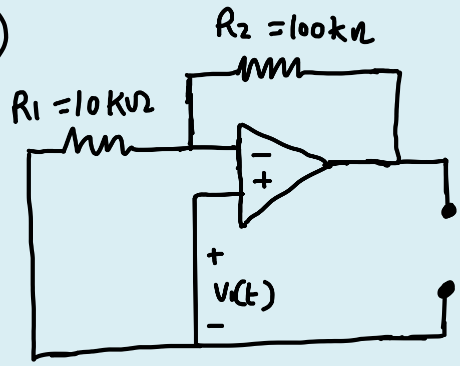
(4) Thevenin Equivalent Output Resistance:

a) Calculate the Thevenin equivalent resistance seen by $v_o(t)$ for the non-inverting configuration shown in Figure 3.0.

b) Calculate the Thevenin equivalent resistance seen by $v_o(t)$ for the inverting configuration shown in Figure 4.0.

c) How does the two equivalent resistances compare?

a)



$$\frac{0 - V_{th}}{100} + \frac{0 - V_o}{10} = 0$$

$$\frac{V_{th}}{100} = \frac{V_o}{10}$$

$$V_{th} = \left(\frac{V_o}{10}\right)(100)$$

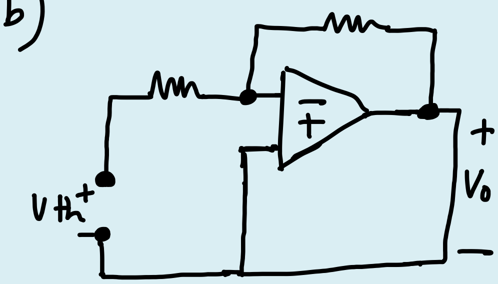
$$= \left(\frac{27.94}{10}\right)(100)$$

$$V_o\, th = 279.4$$

$$R_{th} = \frac{4.81(10000)}{279.4}$$

$$= 172.2$$

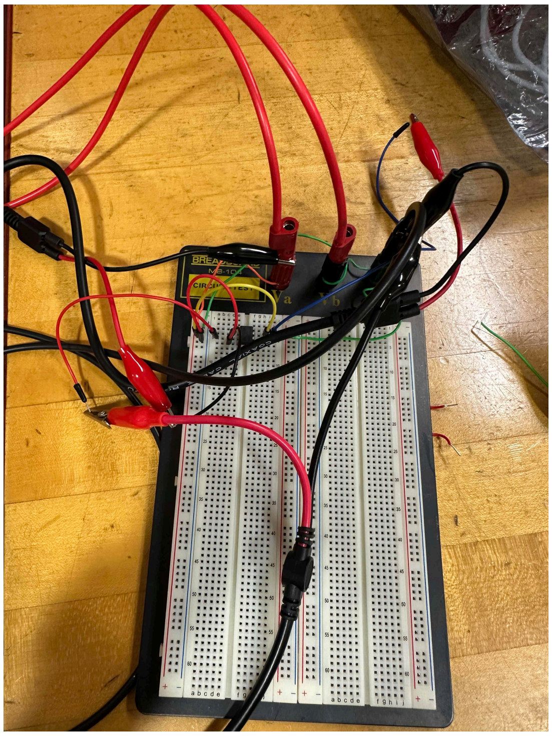
b)

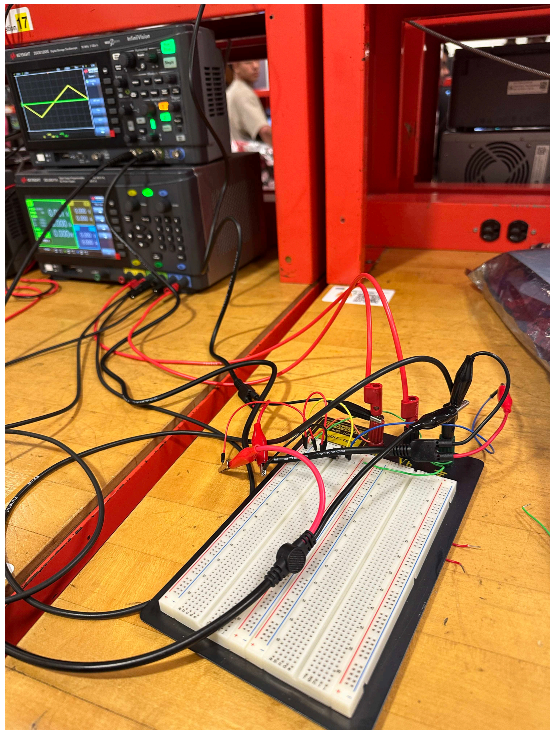


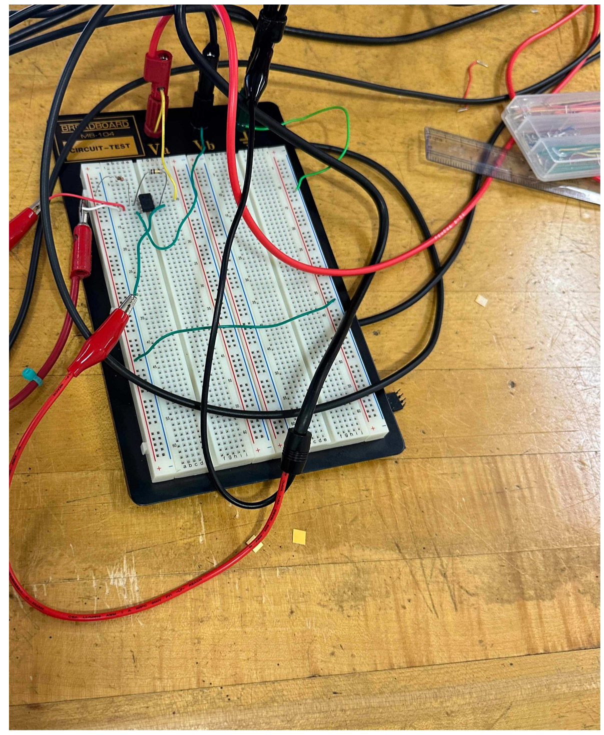
For the inverting circuit the equivalent resistance will be the same as $V_i(t)$.

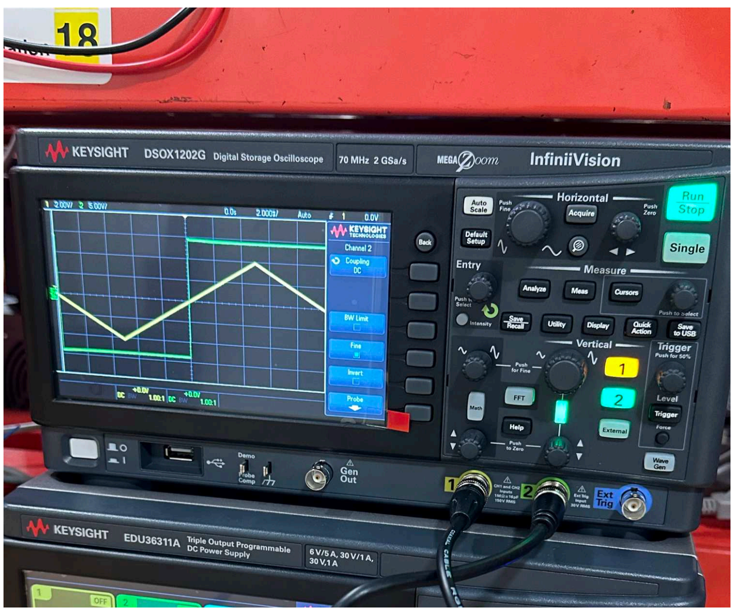
$R_{th} = 11176\Omega$

c) The inverting circuit will have the higher thevenin resistance.

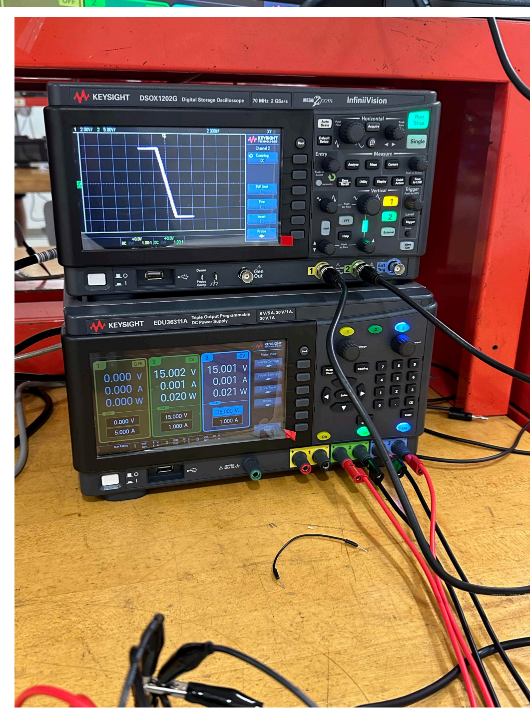


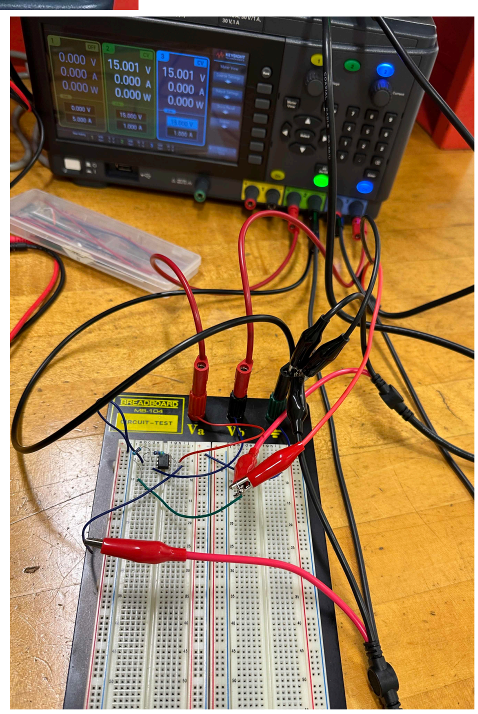





KEYSIGHT
DSOX1202G Digital Storage Oscilloscope
70 MHz 2 GSa/s
InfiniiVision
Horizontal
Measure
Vertical
Trigger
Run Stop
Single
Gen Out
KEYSIGHT EDU36311A Triple Output Programmable DC Power Supply


KEYSIGHT
DSOX1202G Digital Storage Oscilloscope
70 MHz 2 GSa/s
Auto Scale
Default Setup
Entry
Acquire
Time Mode
XY
Acq Mode
Normal
Segmented
Math
Help
Gen Out


KEYSIGHT
15.002 V
15.001 V


15.001 V