Department of Electrical and Computer Engineering
University of Victoria
ELEC 300 - Linear Circuits II

LABORATORY REPORT

Experiment No.: ______________________________

Title: ______________________________

Date of Experiment: ______________________________

(should be as scheduled)

Report Submitted on: ______________________________

(should be within one week from the time of experiment)

To: ______________________________

Laboratory Group #: ______________________________

Names: (please print) ______________________________

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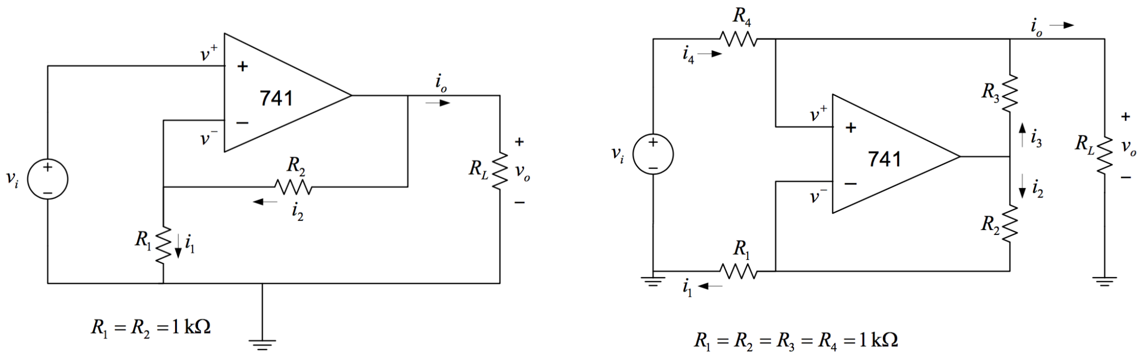
Fig. 0-1. The front page of a lab report

1 Objective

To create two variants of independent sources, both a voltage source and a current source, and analyze their behaviour compared to that expected from theory and calculations.

2 Introduction

Operational amplifiers (op amps) can be used to transform a fixed voltage source into a variable voltage or current source. The output gain, K, of the voltage or current is controlled by the feedback network for the op amp. A voltage-controlled voltage source (VCVS) (Fig. 1(a)) and a voltage-controlled current source (VCCS) (Fig. 1(b)) were created in this lab using an LN741 op amp.



(a) VCVS with $K = 2$

(b) VCCS with $K = 1$ when $R_L = 1\,\text{k}\Omega$

Figure 1: Circuits constructed in this lab [1, p. 17]

Since the VCVS is constructed as a non-inverting amplifier its governing equation is:

$$V_0 = V_i \left(\frac{R_2}{R_1} + 1 \right) = KV_i. \tag{1}$$

Careful application of Kirchoff's Laws yields the following relation for the VCCS:

$$I_o = \frac{V_i}{R}$$

where $R_1 = R_2 = R_3 = R_4 = R$. The output voltage is constrained to:

$$\frac{V_{cc}^-}{2} < V_i < \frac{V_{cc}^+}{2} \tag{2}$$

when $R_L = R$.

3 Results

3.1 Voltage controlled voltage source (VCVS)

A VCVS was constructed following the schematic in Fig. 1(a). ±10 V was used as supply voltage for the op amp. The response of the output voltage to changes in input voltage is shown in Fig. 2.

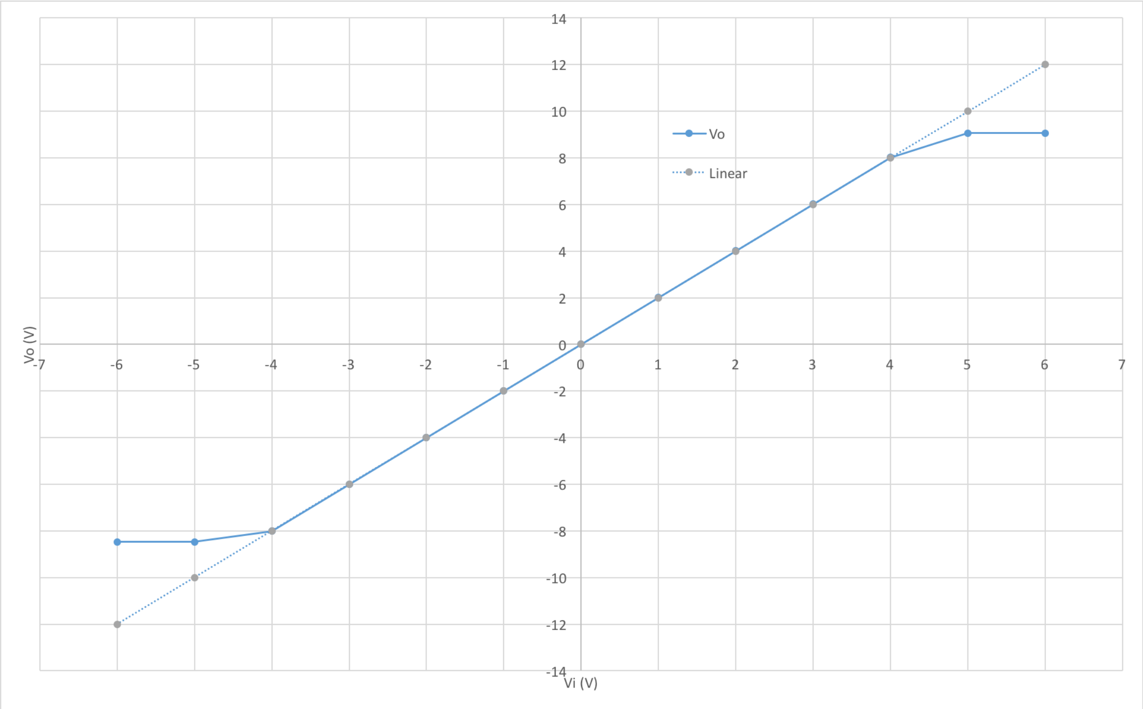


Figure 2: Response characteristic of VCVS with expected linear behavior

3.2 Voltage controlled current source (VCCS)

A VCCS was constructed following the schematic in Fig. 1(b). ±10 V was used as supply voltage for the op amp. The response of the output voltage to changes in input voltage is shown in Fig. 3 for $R_L = 1\,\mathrm{k}\Omega$.

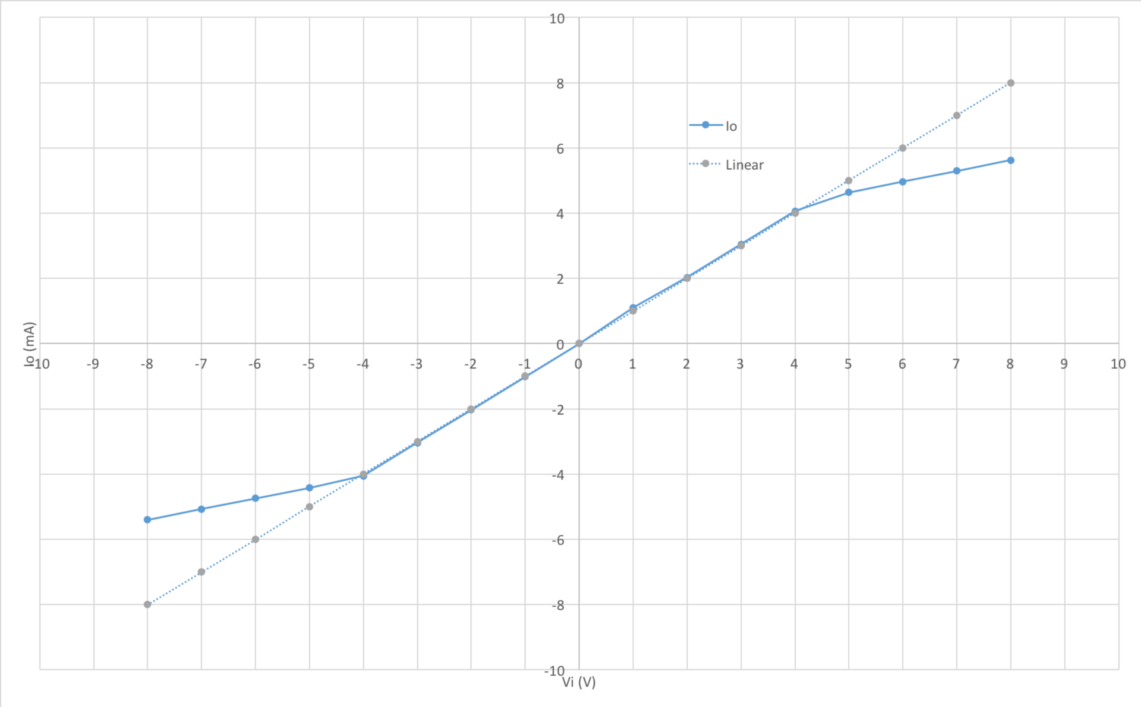


Figure 3: Response characteristic of VCCS with expected linear behavior

4 Discussion

4.1 VCVS

1.3 Does the slope of the straight line agree with the value of K in (1)

Yes, the predicted value of 2 is reflected in the slope in Fig. 2 for $-4.2\text{V} < V_i < 4.5\text{V}$.

Response is capped at expected values on positive side but is lower than expected on negative side. Why?

1.3 Determine the internal resistance of the op amp

When we attempted to estimate the internal resistance using a 150Ω load (R_L in Fig. 1(a)), we were only receiving a drop in voltage of approximately 6µV (peak-to-peak), which implied an internal resistance of approximately 500µΩ: this was considered to be incorrect. Replacing the 150Ω load with a 47Ω load, we experienced a more plausible result. With a load of 47Ω, the voltage across the load was measured to be 788.5mV, which means the source has an estimated internal resistance of approximately 39.1Ω (see (3)).

$$I_o = \frac{V_o}{R_L} = \frac{0.7885\text{V}}{47\Omega} = 16\text{mA}$$

$$V_{internal} = V_i - V_L = 1.4135\text{V} - 0.7885\text{V} = 625\text{mV}$$

$$R_{internal} = \frac{V_{internal}}{I_o} = \frac{625\text{mV}}{16\text{mA}} = 39.1\Omega \tag{3}$$

4.2 VCCS

2.3 Compare the measured range of linear output to the expected range

Evaluating (2) gives $-5\text{V}V_i < 5\text{V}$, whereas we observed a linear region between approximately $-4.0\text{V} < V_i < 4.2\text{V}$. When the edge of the linear region was reached, rather than hard limiting the current experience soft limiting where G dropped to 328×10^{-6}. The asymmetric maxima are most likely the result of a mismatched input impedance. $47\,\Omega$ was used to compensate for $R_{internal}$, which differs from the expected value in (3).

2.4 What is the effect on I_o when $R_L : 1\,\text{k}\Omega \to 0\,\Omega$?

When shorting the output carrying 1mA when measured under a 1kΩ load, the measured current dropped to 0.951mA.

Add a internal resistance calculation. Not sure how to do this eq'n.

Measuring the voltage between the inverting and non-inverting gives a reading of 0.97mV. In comparison to other voltages within the circuit and considering the immense input impedance, the current into each pin is indeed nearly non-existent and certainly negligible.

2.5 Confirm the validity of the ideal op amp assumptions We measured

$$V^+ - V^1 = 0.97\,\text{mV},$$

which is very close to the ideal op amp input difference of 0 V.

5 Conclusion

Justify conclusions and results.

References

[1] P. So and A. Zielinski, *Laboratory Manual for ELEC 300 - Linear Circuits II*, University of Victoria.