LABORATORY EXPERIENCE: Review of Laboratory Techniques

The goal of this laboratory experience is for students to review the concepts learned in previous courses regarding analysis, simulation, building and testing of circuits based on Operational Amplifiers.

Each group will be working on the circuit from Appendix 1 assigned to that specific group.

SECTION 1.- For your assigned circuit do the following activities:

1.1 Simulate the gain (magnitude and phase) of the circuit from 1 Hz to 1 MHz
1.2 Calculate the input impedance of the circuit at about 100 Hz. Verify with simulation
1.3 Calculate the output impedance of the circuit at about 100 Hz. Verify with summation
1.4 Build your circuit
1.5 Measure magnitude and phase of the gain from 1 Hz to 1 MHz
1.6 Measure input impedance of the circuit. Follow the method explained in Appendix 2
1.7 Measure output impedance of the circuit. Follow the method explained in Appendix 3

Compare the simulation versus the experimental results.

SECTION 2. Laboratory report

- Create an individual lab report using the guidelines provided in the course’s website. Include all the information that you believe is necessary.

- Comment on the difficulties and challenges of this laboratory work (i.e. what worked, what did not work, what you liked, what you didn’t like, etc.). Be assured that the grade for your laboratory work or your course will not be affected at all by your positive or negative comments.
APPENDIX 1: Circuits for the different groups

Circuit 1:

Circuit 2:

Circuit 3:

Circuit 4:

Circuit 5:
APPENDIX 2: Measuring Input Impedance of a circuit.

Input impedance of a circuit is the ratio between the voltage applied to the input of a circuit and the current that flows out of the voltage source.

To measure the input impedance of a circuit, we CANNOT use a DMM. Instead, we use the following approach:

Let’s assume that we want to measure the input impedance (Z\text{in}) of the black box shown in the figure below. To do this, we will place an external resistance (R\text{ext}) in series with the input of the circuit and will measure the voltages at both ends of R\text{ext}. Use the oscilloscope to measure these voltages.

![CircuitDiagram.png](attachment:CircuitDiagram.png)

The current flowing into the input impedance is \( I = \frac{V_1 - V_2}{R_{\text{ext}}} \).

Applying KVL we have: \( V_1 = R_{\text{ext}} \cdot I + Z_{\text{in}} \cdot I = (R_{\text{ext}} + Z_{\text{in}}) \cdot \frac{V_1 - V_2}{R_{\text{ext}}} \). From this equation we can solve for the value of the input impedance as:

\[
Z_{\text{in}} = \frac{V_2}{V_1 - V_2} \cdot R_{\text{ext}}
\]
APPENDIX 3: Measuring Output Impedance of a circuit.

We have defined in class the output impedance of a circuit as the impedance seen from the output when the independent sources are disabled. To calculate this value, the place a source at the output of the circuit and calculate the current that flows out of that source.

In practice, however, circuits need their input source to perform as circuits and they complain when we connect a voltage or current source at the output. We cannot use a DMM either. Instead, we will use the following technique.

Let’s assume that we have modeled the output stage of our circuit as a voltage source in series with its output impedance (Zout) that we want to measure experimentally:

First, we measure the output voltage in open circuit and record this value. In this case, because there is no current flowing out of the output voltage, $V_{out} = V_1$

We now connect a variable resistor at the output of the circuit:

Because of the next current path, the voltage measured at the output of the circuit will decrease (there is a voltage drop across Zout). Modify the value of the potentiometer until the voltage that we measure is half of $V_1$. At this point, the value of the potentiometer is equal to the value of the circuit’s output impedance.

**Be careful with a couple of items:**

Select the value of the external potentiometer in a range similar to the expected value for Zout. You may have to reduce the input voltage if the output starts saturating.