LABORATORY EXPERIENCE: Basic Differential Amplifier

The goal of this laboratory experience is to design, test, characterize and evaluate the basic differential amplifier. This type of differential amplifier is the basic building block for the more complete Instrumentation Amplifiers that are used to perform precision measurements.

SECTION 1.- Design of the Differential Amplifier

Design a Differential Amplifier with the structure of the figure below with the following specifications:

- Differential Gain = 20 (+/- 10 %)
- Common-Mode Gain as low as possible. Ideally 0.
- Input impedance seen from each external input at least of 1 kΩ
  (Note.- For this part use only fixed resistors. Do not use potentiometers or resistor boxes)

![Differential Amplifier Diagram](image)

Notes.- Do not use potentiometers or variable-resistance boxes for this basic design

Write down the values for the resistances:
SECTION 2.- Testing and characterizing the circuit

2.1 Measure the differential gain at 1 kHz.
   To measure the differential gain, connect one of the inputs to ground and a signal source to remaining input.
   What is the maximum voltage at the input of the Differential Amplifier that we can allow before the output saturates? Can we achieve this value with the signal generators that we have available?
   If necessary, implement a method to reduce the value of the input signal applied to the Differential Amplifier so the output will not saturate.

   Repeat the measurements interchanging the inputs grounded and connected to the signal

   What are the values of Ad? Are they the same? If not, why?
   If necessary, modify the design of the circuit to make both differential gains as similar to each other as possible. (Use fixed resistors; do not use potentiometers or adjustable resistances)

2.2 Measure the Common-Mode gain at 1 kHz
   To measure the Common-Mode gain, apply the same signal to Vin1 and Vin2 simultaneously

2.3 Evaluate the Common-Mode Rejection Ratio (CMRR)
   What is the measured value of CMRR? What is the theoretical value of CMRR?
   Comment on possible differences

2.4 Minimize CMRR
   Substitute Rd by a resistor box or potentiometer (Use a fixed resistor with a lower value than the originally designed, connecting a potentiometer of resistor box in series. Adjust Rd until the Common-Mode gain reaches a minimum.
   What is the new value of CMRR? (You will need to measure both, Ad and Acm)
   What is the value of Rd that maximizes the CMRR? Comment on your results.
   Can we make Acm = 0? Why?
SECTION 3.- Using a monolithic Differential Amplifier IC (INA 106)

To simplify the design of circuits, it is possible to find in the market Integrated Circuits that perform the function of Differential Amplifier with a minimal number of external components. One of these chips that will be studied in this section is INA106 from Texas Instruments. (INA 106 was first developed by Burr-Brown before BB was bought by Texas Instruments; that's why you can see the BB logo on the chip).

3.1 Study the specifications for the INA 106. What is the gain of the INA 106? What can we do if we need a different value of gain for our purposes?

3.2 Design a differential amplifier with a gain of 10 using the INA 106. Show the design to your instructor before making the connections on your board.

3.3 Build the circuit that you have designed.

3.4 Measure the CMRR at 1 kHz, 10 kHz, 50 kHz and 100 kHz.

3.5 Plot the value of CMRR vs. frequency. Select the type of axis (linear or logarithmic) that better shows the relationship between CMRR and frequency. Compare the frequency behavior with the data from the INA106 specifications.

SECTION 4. 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.

- Once again, please 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.