Lab 6 – Instrumentation amplifier-based Wheatstone bridge temperature sensor

In this lab, you will learn how to use an instrumentation amplifier, and combine it with a Wheatstone bridge to get amplified readings.

Upon completion of this experiment, you will be able to

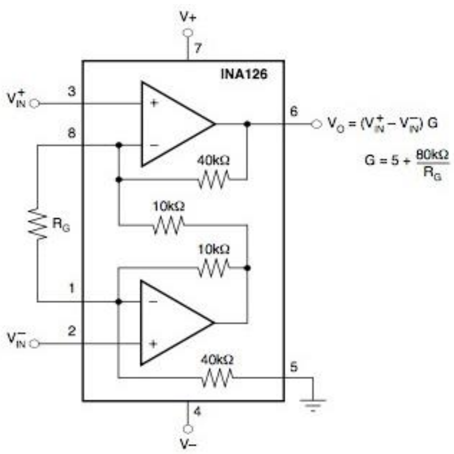
1. Use an instrumentation amplifier with Wheatstone Bridge-based differential inputs.
2. Adjust its operational parameters for getting amplified outputs over specific voltage ranges, allowing for further processing of the output with other devices (e.g. ADCs).

This is a two-part experiment.

Part I

An instrumentation amplifier is a differential op-amp circuit providing high input impedance, and with the ease of gain adjustment through the variation of a single resistor. It is used to provide a large amount of gain for very low-level signals, often in the presence of high noise levels. The major properties of Instrumentation Amplifiers are high gain, large common-mode rejection ratio (CMRR), and very high input impedance.

Instrumentation Amplifiers can be made using a 2 op-amp configuration or a 3 op-amp configuration with each configuration having different CMRR and input impedance. INA126 is one such instrumentation amplifier which uses 2 op-amp configuration.



Internal Schematic of INA126 Instrumentation Amplifier (Source: ti.com)

In this lab activity, you will build an Instrumentation Amplifier circuit based on the INA126. As it will be used with time-varying signals as inputs, you will obtain its frequency response for different gains using an oscilloscope. In doing so, you will note that there is a trade-off between the gain and bandwidth of operation of the amplifier.

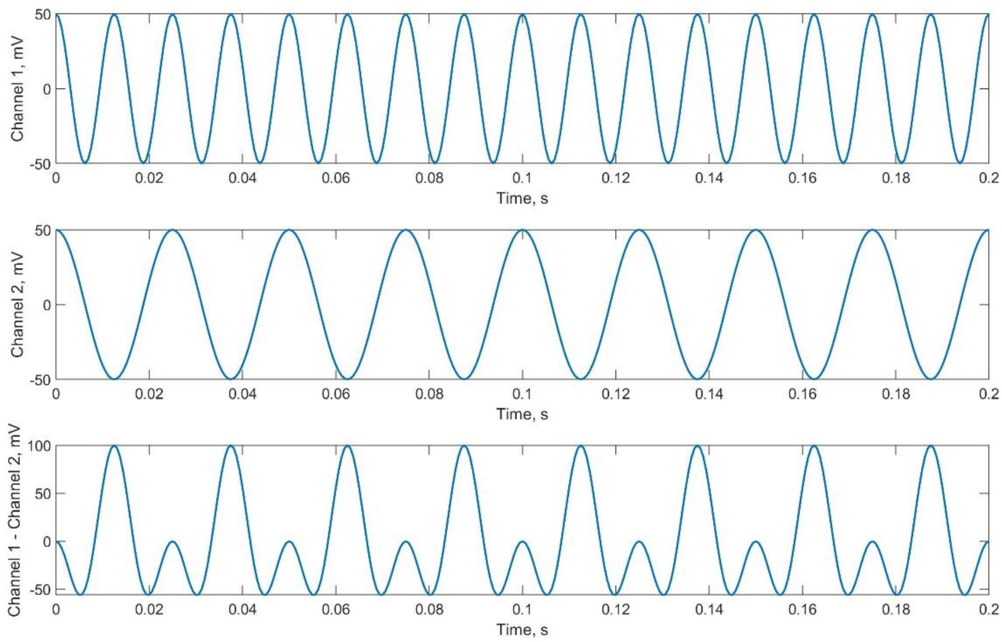
As the INA126 is a differential amplifier, you will need to provide two inputs to it. You can either use two inputs, or use a voltage divider circuit to get two signals of same frequency but different amplitudes as the input signals.

IMPORTANT – Study the datasheet of the INA126 to see how to connect the different inputs and output probes, and note its maximum ratings.

Part I - Tasks

- **Task 1** – Build the complete circuit diagram of the amplifier circuit on the breadboard and get it verified by your Instructor/TA. You don't need to add the gain resistor at this stage.

- **Task 2** – You will provide a differential input to the amplifier using two channels of the signal generator. For the non-inverting input of the amplifier you will provide a 80 Hz, 50 mVpp signal, and a 40 Hz, 50 mVpp signal for the inverting amplifier input. You will perform this task in two stages.
    - **Stage 1** – You will take the outputs directly from the signal generator, and connect it to the oscilloscope. Using the in-built math function of the oscilloscope, you will see record the expected difference signal. You should see signals which should look something like below.



    - **Stage 2** – You will now connect the respective channels from the signal generator to the inputs of the amplifier. Verify the output of the amplifier for no gain resistor, and a further four values of gain.

Show the results to your TA/Instructor.

Task 3 – Keeping the circuit unchanged, replace the mains supply voltage source with two 9-V batteries that are provided to you. Verify that the circuit works as expected by comparing it with the results obtained in Task 2. Show your results to your TA/Instructor.

Task completion criteria

1. You build the Instrumentation Amplifier circuit with the gain resistor R_G as input parameter and cross-verify the value of the gain obtained with your TA.
2. You demonstrate the working of the amplifier when it is battery operated.

Part II

Task 1 - Construct a Wheatstone bridge for a PT100 sensor, such that

a. You are using the same battery that is being used for the INA as the voltage source for the bridge. The supply voltage should be 1.5 V.
b. The Wheatstone bridge is operating in (approximately) its maximum sensitivity configuration.

Task 2 - Connect the PT100 sensor to the Peltier configuration like the last class. You will have to redo both the calibration of the Peltier and the PT100, as the experimental configuration will no longer be the same as the previous class.

Task 3 - Connect V_b and V_d of the Wheatstone bridge to the inputs of the instrumentation amplifier. Obtain the transfer characteristics of the Wheatstone bridge-instrumentation amplifier, as you vary the temperature of the Peltier, for three values of amplifier gain –

a. Without any gain resistor.
b. Gain such that the output covers the operational range of your temperature span corresponds to an amplifier output voltage range of +/- 5V.
c. **Maximum gain** that will cover the operational range of your temperature span.

You will show the three transfer characteristics on a single plot, where the x-axis is temperature, and y-axis is the output voltage of the instrumentation amplifier.

Task completion criteria

3. You build the Wheatstone bridge as per the specifications.
4. You calibrate the Peltier and Wheatstone bridge, and produce the corresponding graphs.
5. You produce the Wheatstone bridge-instrumentation amplifier configuration transfer characteristics (V vs. T), for three values of amplifier gain as indicated above.