Component Level Laboratory

Analog Signal Conditioning Fundamentals:

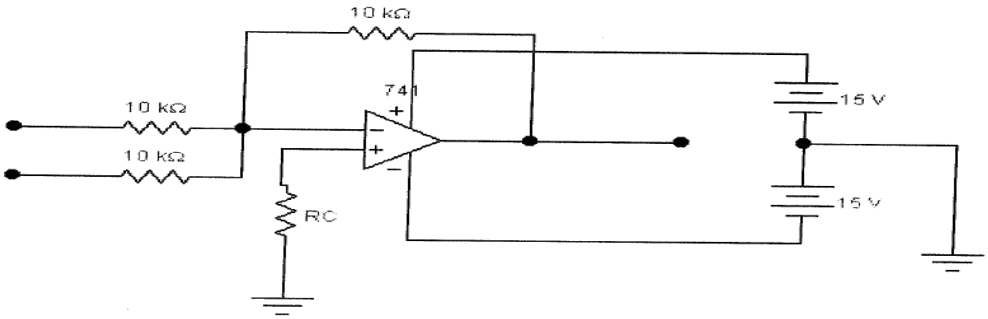
Op Amp Signal Conditioning Circuits and Linearization)

Objective

The objective of experiment is to learn the functions of Op Amp summing circuit and the nonlinearity of sensor signals. Build Lab view VIs to linearize the sensor signal. Then an Op Amp based signal conditioning circuit will be designed and implemented on breadboard. Finally, learn the Graph VI and Bundle VI in Lab view.

1. Linear Combination (Summing) Op Amp Circuit

For the Op Amp circuit shown below,



(1) Write the equation of the output voltage Vout in terms of input voltages (V_1 and V_2).

Vout = _____

(2) Apply a negative DC voltage to one input (V_1) and a 1kHz AC sine wave to the other input (V_2); write the equation of Vout in terms of the input voltages.

Vout = _____

2. Nonlinearity and Linearization

A sensor outputs an electrical quantity such as resistance or voltage that changes with the variation of the physical phenomenon it measures. Often time, such relationship is nonlinear. For example, Figure 1 shows the voltage output of a displacement sensor. It is clearly shown the voltage output (0-10V) does not correlate with the displacement (0-10cm) linearly. From the figure, we can see that the sensor outputs 8 volts for a displacement of 5 cm; and outputs 5 volts for a displacement of 2 cm. Furthermore, even though sensor provides output that linearly correlated to the physical variable it measures, the signal conditioning we have to use afterwards introduces nonlinearity.

With nonlinear relationship, it is harder to determine the value of the physical variable from measurement. The ideal situation is to have linear relationship as shown in Figure 2. In this case, the sensor output of 0 to 10 volts corresponds linearly to the displacement from 0 to 10 cm. With the modern computer, such linearization can be provided using software.

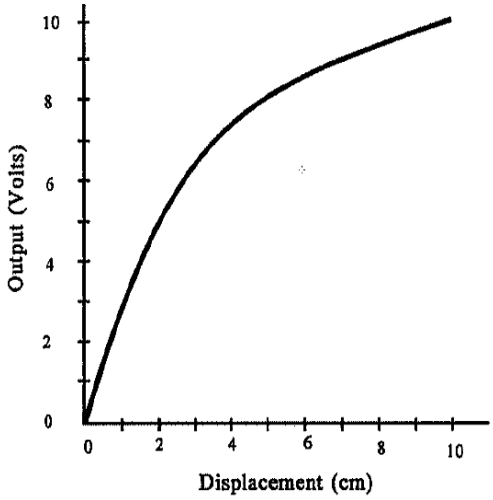


Figure 1 Nonlinear Relationship between sensor output voltage and displacement

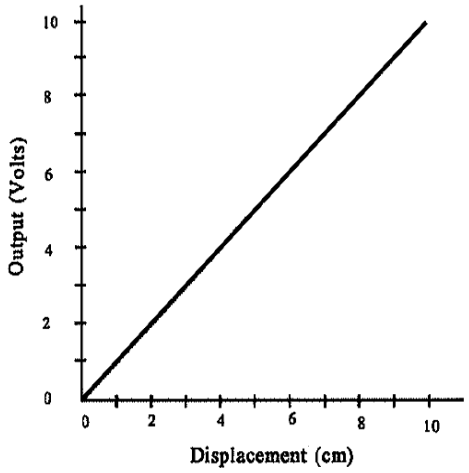
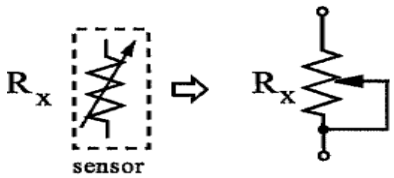


Figure 2 Linear Relationship between sensor output voltage and displacement

To study the concept of nonlinear relationship between sensor output and the measured physical variable, we will use a *simulated* sensor whose resistance, Rx, varies ***linearly*** from 0 to 5kΩ. We assume that the change of the resistance is resulted from linear displacement, x, from 0 to 1cm. The linear transfer function of the sensor is: Rx = 5000 x.



Exercise 1. Conversion from sensor resistance change to voltage change

Design an analog signal conditioning circuit that can convert the resistance change of the displacement sensor to voltage change. Identify the relationship between the displacement and the voltage output of the sensor (i.e., Vx = f(x)). Is the relationship linear or nonlinear?

(Hint: You can use either voltage divider or wheat stone bridge to realize the conversion.)

Exercise 2: Design Op Amp circuit to convert the voltage change to 0 to 1Volt

Design a linear signal conditioning equation that will convert the output Vx from your circuit to Vs, which linearly changes from 0 to 1 volt when the displacement x changes from 0 to 1cm. Identify the equation between Vs and x: Vs. = g (x). Design the Op Amp Circuit to implement the linear equation.

Reminder: Bring your breadboard to the lab!