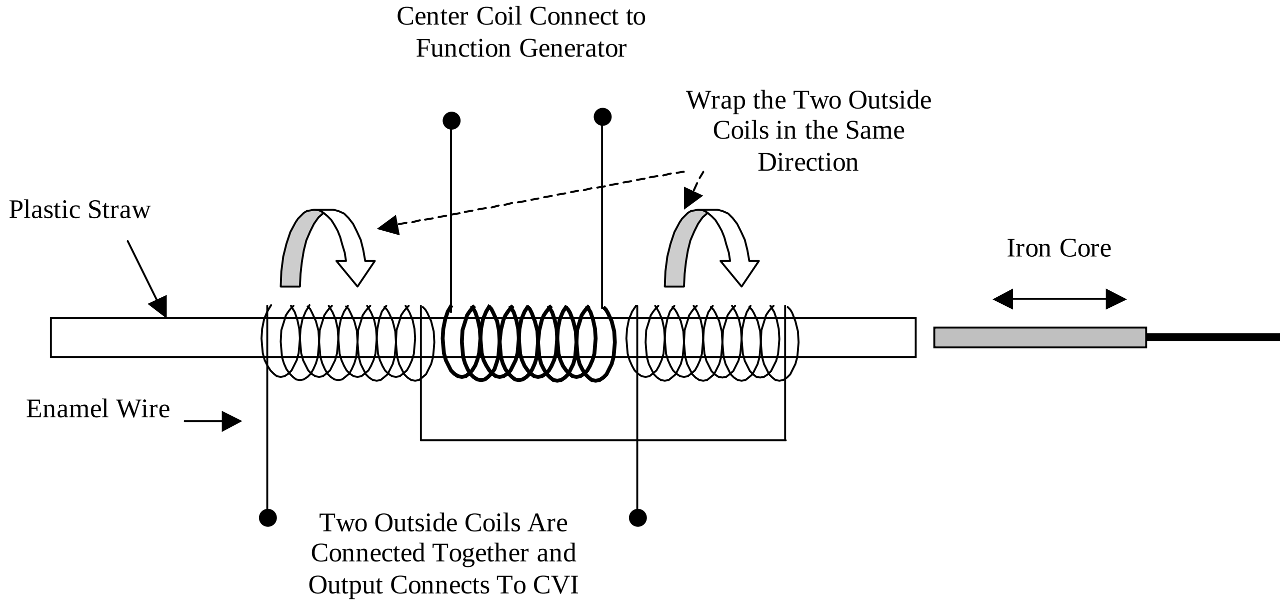
Mechatronics I Laboratory Exercise 9

LVDTs

An LVDT or Linear-Variable-Differential-Transformer is position-measuring sensor. There are several advantages of LVDTs over potentiometers. LVDTs have no surfaces in direct physical contact so there can be no dirt or liquid interrupting the conduction path. As there is no direct contact, there is no wear of a wiper or conducting surface. They also have minimal drag and are limited in resolution only by electrical noise. LVDTs are composed of three coils of wire wrapped in line on a cylinder (see Figure 1). The center core is the exciter coil in which an AC current is applied. The coils on each side of the exciter coil are the detector coils. An iron core is moved inside the cylinder. As the iron core is moved between the exciter coil and one of the detector coil more current is induced into the detector coil and less current is induced into the opposite detector coil. The position of the iron coil is determined by looking at the difference between the induced current in each of the detector coils

Figure 1. LVDT Construction Using Enamel Wire, Plastic Straw and Iron Core.



In this exercise you will also use an instrumentation amplifier to demodulate the signal from the LVDT. Note that the LVDT output was an AC signal. You will build a (demodulation and filter) circuit, which will give a DC signal as the output. The key to the demodulation is a rectifier. A rectifier is a bridge (similar to the strain gage bridge) of diodes (see Figure 2). Note that a diode only lets current to flow in one direction -- Figure 3 shows a rectifier bridge

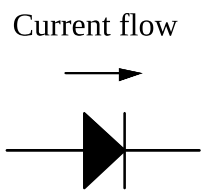


Figure 2 Direction of current flow

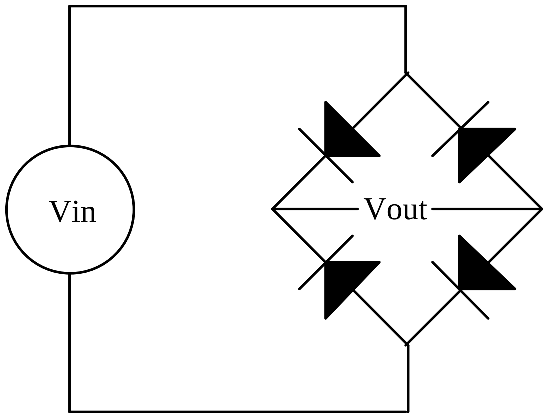


Figure 3. A rectifier bridge

You will build two rectifiers and connect each of them to each of the output coils of the LVDT that you built. Refer to the LVDT lab handout (Figure 3.6 of the attached copies) to see the connection of the rectifiers to the LVDT. This circuit will produce a rectified AC signal from the LVDT. In order to smooth this signal to make a DC signal, you will add a capacitor to the feedback of the last stage of your circuit to make an active low-pass filter. This is shown in Figure 4.

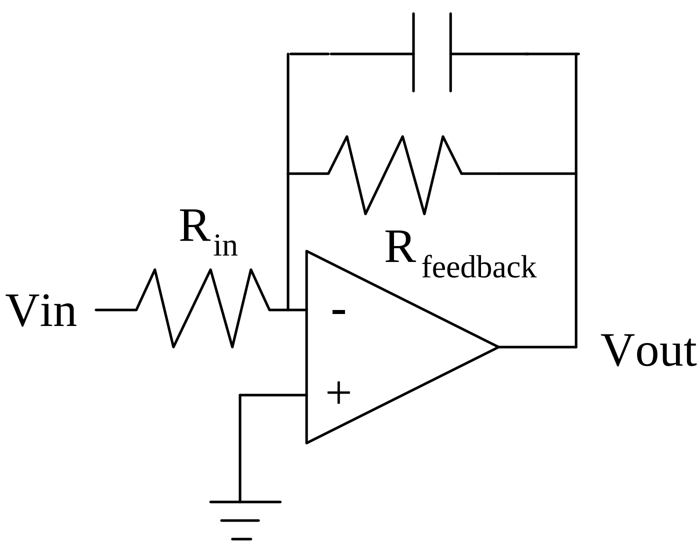


Figure 4. An active low-pass filter

Laboratory Exercise

Equipment Needed: Function generator, oscilloscope, plastic straws, enamel wire, steel rod, breadboard, and multimeter.

1. Wrap three coils of enameled wire on the cylinder as shown in Figure 1 below. Make at least several hundred wraps on each coil set. Tape the coils in place. Strip the enamel from the ends of the wire. Place the iron core into the cylinder. Connect the function generator to the center coil. Start CVI LabWindows and open the project "lvdt.prj" from the "C:\CVI\PROGRAMS\LABS\LVDT" folder. Connect the output from your LVDT to **AI_CH0** of the A/D board and to the oscilloscope. Ensure that the sampling rate is high enough to avoid aliasing. Press "Start" and look at the output voltage of the LVDT and save your data. Repeat the process as you move the iron core within the straw and

save your data. What’s happening to the amplitude of the LVDT as you move the iron core and why? Is the relationship, between the motion of the iron-core and the amplitude of the output-voltage, linear?

2. Build the rectifier-bridge and connect them to the LVDT. Connect the circuit as shown in the LVDT lab handout. Connect the output of the LVDT/rectifier circuit to your instrumentation amplifier circuit.
3. Look at the output of the amplifier on the oscilloscope and collect data using CVI LabWindows and save your results. Do this for several positions of the iron core within the LVDT. Plot your data and explain.
4. Add the capacitor to the last stage making an active low-pass filter and look at he output on CVI. Save your results for several trials. Plot your data and explain your results.
5. Make a calibration of your LVDT system. Find the output voltage as a function of the displacement of the LVDT core.
6. Calculate the gain (from the transfer function) of your OpAmp circuit and compare with the measured gain.

Post-Lab Report

Discuss your results. What are some applications of LVDTs? Discuss some advantages and disadvantages of LVDTs? What did you see at the output of the amplifier (part 3)? What effect did the capacitor have on the circuit? Compare and contrast theoretical and experimental gains (part 6) of the OpAmp circuit. Include relevant circuit schematics and plots to support your conclusions.