

# Mechatronics I Laboratory Exercise 1

## Computer Data Collection

In this Laboratory exercise, you will use a computer as the primary data and signal measuring system - this exercise serves as an introduction. There are two main concepts that you must explore: resolution and sampling rate.

### Resolution

Analog-to-digital converters (A/Ds) convert a voltage to a digital word for the computer to read. A/Ds are specified by their resolution and their speed. The resolution is finite and is given as a number of bits such as 8-bit or 12-bit or 16-bit. This specifies the number of levels that the A/D can read over its range. The number of levels is 2 to the power of the number of bits. For example, an 8-bit A/D has  $2^8$  levels or 256 levels, a 12-bit A/D has  $2^{12}$  or 4096 levels. The range of the A/D is the maximum and minimum voltages that it can read. For example, the range of a A/D might be -10 volts to +10 volts. This means that the range is 20 volts ( $\pm 10$  volts). The resolution is the range divided by the number of levels. A 12-bit A/D with a range of  $\pm 10$  volts would have a resolution of 4.88 millivolts (mV). What this means is that this A/D can discriminate a difference of 4.88 mV.

### Sampling Rate

The sampling rate or speed of the A/D is the other important factor. A/Ds do not convert the voltages to numbers continuously at all instants of time. Conversions are typically done at discrete times - the time between two measurements is called the sampling time. Sampling rate is number of samples per second. The evolution of the signal between any two sampling instants is not seen by the A/D. For example, if the sampling rate is 1000 samples/sec (sometimes Hz is used), then the signal is read every millisecond. It is very important that the sampling rate is sufficiently fast for the signals being monitored. If the sampling is too slow, aliasing will occur.

### Laboratory Exercise

Equipment Needed: Function Generator and oscilloscope.

1. Start CVI LabWindows (click the CVI LabWindows icon on the desktop) and open the project "DATA\_AQ.PRJ" from "C:\CVI\PROGRAMS\LABS\DATA\_AQ" folder. You should see three files on the CVI console, DATA\_AQ.C, DATA\_AQ.H, and DATA\_AQ.UIR. If you cannot locate these files, consult your TA.
2. Connect the output from the function generator (**labeled 600 $\Omega$  Output**) to **AI CH0** of the A/D board (box on workbench with colored banana plugs). Also, connect this output to the oscilloscope-input channel **A**. Ground the function generator to **AI\_GND** on the A/D board and to the oscilloscope.
3. Turn on the function generator and use the oscilloscope to verify that you have a 20 Hz,  $\pm 4.0$  volt sine wave. Run the CVI project by selecting *Run/Run Project*. You should see a workbench panel appear labeled "Computer Data Collection Lab".
4. Set the sampling rate to 200 Hz and number of samples between 40-70. Press start to measure the sine wave. After a few seconds, you should see a plot of the input appear on the graph display. Save the data on your own floppy disk. The data is saved in two columns, the first column is the time and second column is the voltage data measured by the A/D card. Plot the signal with appropriate

labeling of the axes. You may use any plotting routine that you have available and find out how you can incorporate the plot directly into a word processing document. All of these applications are available to you in the lab but you may wish to try this on another computer. What is the frequency of the measured data? Is it consistent? Why does the signal look “jagged”? How can you make the signal appear smoother?

5. Repeat exercise steps 1-4 using a 20 Hz,  $\pm 10$  mV sine wave (sample rate of 200 Hz and number of samples between 40-50). The function generators are not capable of a 10mV signal, so a voltage divider circuit is required to properly scale down the sine wave. Turn the "Amplitude" knob on the function generator so that you get the smallest output. Connect the output from the function generator to the voltage divider circuit shown in Figure 1. Ask your TA for help if you have trouble. Run the program and save your data. . Explain why there is a difference in the appearance of the sine wave in the post-lab report. What's happening?
6. Finally, record a 20 Hz ,  $\pm 4$  volt sine wave at a sampling rate of 20 Hz and number of samples set to 50. Save your data. What is the frequency of the measured signal and why? Explain your observations and results in the post-lab report.

## Post-Lab Report

- 1) The laboratory A/Ds are 12 bit with an input range between -5 to +5 volts. What is the resolution of the A/Ds in the laboratory computers?
- 2) Assume you are measuring a sinusoidal signal of frequency 10 Hz. Through MATLAB simulations determine a suitable sampling rate (you may use other Software).
- 3) Discuss your results from the above steps. Include plots and interpret the plots.