1.103 CIVIL ENGINEERING MATERIALS LABORATORY (1-2-3)

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LABORATORY ASSIGMENT NUMBER 1

MEASUREMENT DEVICES AND DATA ACQUISITION

Purpose:
 (1) Gain exposure to typical laboratory instrumentation.
 (2) Develop skills in digital data reduction.
 (3) Calibrate common transducers and evaluate results.
 (4) Compare different analog to digital conversion techniques.

Reading:
 • Introductory chapter on DC circuits from basic electronics text (e.g. Basic Electronics for Scientists by Brophy, Ch. 1).
 • Chapter on analog to digital conversion (e.g. Interfacing by Derenzo, Ch. 3).
 • Chapter on simple sensor technology (e.g. Interfacing by Derenzo, Ch. 4).
 • The attached material with this assignment.

Part A: Digital Data Acquisition System

Most of the measurements which will be made for this laboratory class in the coming months will make use of electronic transducers and analog to digital conversion devices. That is to say we will be making measurements with the aid of computers rather than writing everything down by hand. This first laboratory is designed to provide you with exposure to the basic technology and to develop a working understanding of our equipment. For this part of the laboratory you will evaluate the characteristics of the data acquisition by measuring the time history of readings for a variety of conditions. For each electrical configuration collect measurements as indicated in the attached Table 1.

Electronic Configurations
The performance of the data acquisition system often depends on the specific details of the electrical circuit as well as the type of transducer and the wiring. You are to make measurements using three configurations as specified below. The lab bench contains all the necessary wiring to make these measurements. You must change the wiring for each electrical configuration.

Open circuit - the high and low sensor wires are not connected to anything and hence allow the system to drift randomly. This configuration allows you to measure the inherent quietness of the system.

Short circuit - connect high and low sensor wires together, thus producing zero voltage. This serves as a calibration point and also measures the circuit stability without the influence of a transducer.

Load cell - Connect the load cell to the high and low sensor wires. Take measurements with the transducer sitting on the table. This adds the real application of the device. This type of system evaluation is <u>specific</u> to the particular type of transducer.

Displacement Transducer - Connect the output of the displacement transducer to the sensor wires of the system and make measurements with the shaft removed and the transducer on the lab bench.

Signal Amplification - Signal amplification or gain is a method to improve the signal resolution. The signal from the transducer is increased by a constant value before it is input into the analog to digital converter. The output of the converter must be divided by the gain in order to return to the original signal value. This method only improves the signal to noise ratio if the noise is in the actual conversion part to the system.

<u>Data Acquisition System</u>
The attachment to this assignment presents the significant technical details for analog to digital converter that is located inside the computer. The following paragraph is for guidance in the laboratory and should be used to setup each data file. Depending on your experience with computer applications, you may find it quicker to collect multiple sets of data in one file. If you do chose to combine data sets be careful to take good notes about the physical set which matches with the readings.

The Analog Devices 1170 on the MADC
This is a generic card designed by T.C. Sheahan in our geotechnical laboratory several years ago. We use this equipment because of the high bit precision and the ability to change the integration time. We will use software written specifically for this laboratory.

- Turn on PC.
- Change directory to 1103LAB.
- Run program Quick Basic by typing QB.
- Load the program by pressing ALT, then File, then TAB.
- Use the arrow keys to select DAP1170.bas.
- Press ENTER to accept and the computer code will appear.
- Run the program by pressing ALT, then RUN, then START.
- Select options for the specific run.
- Collect 50 readings for each of the conditions specified in Table 1.
- For each condition you need to rerun the program.

Data Processing:

- Copy each data file over to a disk.

- Use Lotus, Excel, or any other program to plot the raw data versus time and compute the mean voltage and standard deviation for each condition (generally 50 readings). You only need to present (in your report) plots which have significant information. Do not waste the paper to present plots of such things as constant readings versus time.

- If the data are valid then compute 1) mean, 2) standard deviation and 3) the bit resolution. Compute the bit resolution using a converter range of +/- 5 volts and the number of bits you input into the computer while collecting the data.

- Complete a matrix similar to Table 1 with your results expressed in volts and engineering units for the two transducers.

- How does integration time effect the results?

- How does bit precision effect results?

- Does the gain improve the measurement or not?

- Why is important to control the distance between the transducer and the power supply but not the distance between the data acquisition system and the transducer?

Part B: Calibration of Measuring Devices

Displacement Transducer

a) Power up the transducer with 5.5 volts; allow sufficient time for the output voltage to become stable usually 10 min.

b) Manually move the shaft and observe the output cycles.

c) Connect the transducer to the calibration block; the micrometer is used as the reference (ie. it is taken as the true value).

d) Cycle the transducer to be sure everything is functioning properly (it should produce about +/- 2 volts over its usable linear range).

e) Record the actual input voltage.

f) Set the data acquisition system for 10 to 20 second interval and 300 readings of both the transducer channel and the input voltage.

g) Starting at one extreme of the linear range incrementally move the assembly towards the opposite limit in pre-selected increments. Be sure the system is at the reference point when the computer takes a reading.

h)   Obtain about 20 points over the range of the transducer to establish this relationship.

i)   Continue taking data at the same reference locations as you return to the starting location and then perform a second complete cycle.

Load Cell Transducer

a)   Power up the transducer with 5.5 volts; allow sufficient time for the output voltage to become stable usually 10 min.

b)   Assemble the transducer in the load frame using the extension shafts and the ball bearings as moment breaks.

c)   Balance the arm by turning the screw until the knife edges are aligned. Be sure the bottom fulcrum loading pin is centered.

d)   Load the device to capacity and unload to zero several times.

e)   Record the input and initial output voltage. Notice that this does not correspond to zero load.

f)   Set the data acquisition system for 10 to 20 second interval and 300 readings of both the transducer channel and the input voltage.

g)   Incrementally load the transducer to capacity. Remember to balance the arm at each load and center the bottom fulcrum loading pin.

h)   Continue taking data at the same reference forces as you return to the starting value and then perform a second complete cycle.

Data processing for each transducer

a)   Data are stored by the data acquisition system in a file which is designed to be imported into a spread sheet program such as Excel or Lotus. The first column of data will correspond to time in seconds. The remaining columns will contain data for each specified channel.

b)   Create a new column for the reference applied to the transducer and input the values corresponding to each data row.

c)   Create another column corresponding to the normalized output (transducer output divided by the input voltage for each line of data).

d)   Plot the normalized output of the transducer versus the reference value. Check for obvious errors (data points way off a straight line) and modify the data as required. It is normal to miss a reading or have two readings at one reference value. These erroneous lines of data should be deleted before proceeding with the analysis.

e)   Use the statistical data functions to calculate the calibration factor (slope of the line).

f)   Use the statistical data functions to calculate the goodness of fit (r^2).

g) Calculate and plot the hysteresis versus the reference value. The hysteresis is computed as the difference between the average of the two increasing normalized output values and the decreasing normalized output values at each reference value.

h) Calculate and plot the nonlinearity versus the reference value. The nonlinearity is the difference between the linear regression line and the average of the four normalized output values at each reference value.

i) Calculate and plot the repeatability versus the reference value. The repeatability is the difference between each pair of normalized output values at each reference value.

Table 1: Parameters to measure Data Acquisition Stability

Integration Time	Open Circuit	Closed Circuit	Load Cell	Displacement Transducer	Bit Resolution
1ms			yes[1]	yes	12 & 18
10ms			yes		18
16.7ms			yes		18
20ms			yes		18
100ms			yes		18
166.7ms	yes	yes	yes[1]	yes[1]	18
300ms			yes[1]		18 & 22

Note 1: for these conditions collect data with a gain of 100. Be sure the signal is below 45 mv or the amplified signal will to out of range.