PROCESS CONTROL
Equipment Familiarization and Calibration

Introduction:

The two-tank process control set-up can be operated in a number of ways via the use of controllable pumps, valve settings and software options. The computer may be used to control the process by regulating pump speed and may also be used for data logging purposes. In this exercise you will be introduced to the equipment and will calibrate the pumps and level sensors and make use of a data logging program, PDL. You will then use the spreadsheet program EXCEL to process the data.

Experimental:

The laboratory instructor will provide an overview of the equipment and its operation and demonstrate the computer programs to be used. Three data files will be generated by following the procedures outlined below.

A: Pump Calibration

The pumps may be operated either manually or under computer control. Under computer control the control program provides a decimal value which is sent to a Digital-to-Analog Converter (DAC) the output of which controls the speed of the pump. The variable speed pumps are equipped with a digital read-out (LED's) which may be used, after calibration, to determine the delivery rate of the pump.

In this calibration procedure you will be deriving the relationships among:
1. DAC input values,
2. Pump flow rate, and
3. LED Reading.

DAC input values will be entered using the program DACDRV.

Procedure:

Pump Calibrations:

0. Turn on Power supply located between the two systems.

1. Start the DAC driver program, DACDRV. Set the pumps for external control and start Pump 1.

2. Set the valve to deliver the output from pump 1 to Tank 2 and supply values of 500 to the DACDRV program.

3. With the level in Tank 1 near zero (valve closed), direct the flow from pump 1 to Tank 1.

4. Record the elapsed time for the level to rise from 5 cm. to 25 cm. and also record the LED reading.

5. Repeat steps 2 through 4 for DAC settings of 1000 and 1500.

6. This completes the data acquisition for calibrating pump 1. Turn Pump 1 off.

7. Repeat procedure, starting at step 2, for pump 2.

8. Terminate the DACDRV program.

You now have the necessary data to derive relationships among the three quantities noted above.

B: Pressure Sensor Calibration

The differential pressure sensors are used to determine liquid level and volume of liquid in the tanks. The output voltage of the sensors is reasonably linear with respect to pressure. Hence, the voltage output may be assumed to be linearly related to height and volume. The object in this calibration is to obtain a table of liquid levels and the corresponding voltage output as measured by the Analog-to-Digital (ADC) converter in the computer / process interface.

Procedure:

1. Activate the PDL program (PDL_L or PDL_R) for the current (Left or Right) Station. When asked, press enter to use the default parameters. Choose option 9 to commence data logging.

PDL Readout
Columns 1-3 = time
Columns 4 = Tank 1
Column 5 = Tank 2

2. Fill the tank associated with the sensor to be calibrated.

3. Lower the liquid level until you can first make an accurate reading of the level and record the reading given by the PDL for the tank in question.

4. Continue the procedure of lowering the level and taking ADC readings, at relatively equally-spaced intervals of height until the level is near the end of the scale attached to the tank. A total of five, Height - ADC Reading data points will be sufficient for the calibration.

5. Obtain a similar set of readings for the sensor on the other tank.

6. Conclude data logging by clicking on the Options dialog box and proceeding as above for the second tank.

7. Terminate the PDL program.

NOTE: The PDL program is continuously reading the ADC signal from the 2 pressure sensors. You will only be using the program as a tool to read the ADC outputs. For the next section you will utilize the time interval ADC readings to check your calibrations.

The file thus generated by the PDL program may be used as a back-up for the ADC readings read from the screen and will be most useful if the experimenters pause sufficiently at each height to allow the “capture” of three or four ADC readings.

C: Obtaining data to test the above pump and pressure sensor calibrations.

Procedure:

1. Activate the PDL program and name the file to be generated. When asked, press enter to use the default parameters. Choose option 9 to commence data logging.

2. Set pump 1 to internal control and an LED reading of 700. Direct the output from the pump to tank 2.

3. Beginning with a nearly empty tank, direct the output of pump 1 to tank 1 and allow PDL to obtain a log of ADC readings vs. time.

4. When the level reaches approximately 30 cm, conclude data logging for pump 1 by clicking on the Options dialog box and selecting "Stop Program; Get Menu".

5. When the menu appears, choose Option 7 to close the current file and create a new file. The first file will have a file extension of '.000'; each succeeding file will have a file extension one unit higher; e.g., .001 for the second file.

6. Repeat steps 1 through 5 for Pump 2.

7. Turn off pumps.

8. Terminate the program.

Search for your file on the computer hard drive and copy either to disk or to your Scrutinizer account.

Data Processing:

A. Pump Calibration:

Load the pump calibration data for one of the pumps into EXCEL in the form of a table:

DAC	Flow	LED Rdg.
500	-	-
1000	-	-
1500	-	-

Flow readings are to be derived from the timed rise of the liquid level and the knowledge that the cross-sectional area of the tanks is 51.8 cm^2.

Prepare the following charts:

1. Flow vs. LED Reading,
2. Flow vs. DAC setting, and
3. DAC setting vs. LED Reading.

Use the "Insert Trendline" function to calculate the Least-Square fit for a linear correlation and display the resulting equation on the chart. Print the charts and repeat the above for the other pump.

B. Sensor Calibration:

Using EXCEL prepare a table of 'Height vs. ADC Reading' for each of the two sensors. Using the linear correlation feature of EXCEL as above, prepare a plot of the data for each sensor. Print the two charts and include the correlating equation along with the R squared value for the fit.

C. Flow-Rates using ADC vs. time data:

The relationships derived above in 'B' may be used to convert ADC readings to height. This relationship is in fact what is employed by the process control program in reporting tank height data. Using the ADC readings vs. time data from Experimental Part A, calculate the flow rate for an LED reading of 700. How does this value agree with the data obtained by timing the level rise?