

# Experiment 7: Feedback Control 2

(tbc 4/2/2007)

**Objective:** To implement a proportional-integral control system to control tank level.

## I. Experimental Setup

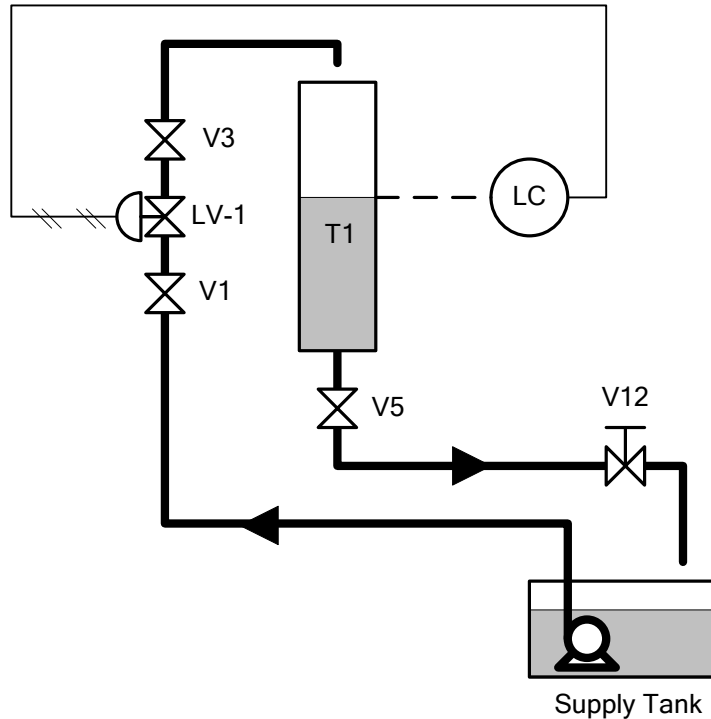


Figure 1.

## II. Procedure/ Tasks:

1. Make sure the water supply tank is filled with water (use sight glass).
2. Connect the compressed air supply, open valve V-19, and set the pressure regulator to 17 psig.
3. Make sure tank T1 is empty before starting.
4. Close all valves except valves V1, V3 and V5.
5. Turn on the pump.
6. Load `c:\Labview\cm3310_2k7\TANK_LEVEL_PI_CONTROL.vi`. Figure 2 shows the front panel.



Figure 2.

(See Appendix A for the Block Diagram window corresponding the VI.)

7. Switch to manual control by selecting (clicking) Auto button to OFF. Enter 45(%) in the Manual (%) dialog box. Run the VI. (A window should open, requesting a filename to save the data.)
8. Wait until height approximately 8 in. then turn valve V-12 (initially closed) one counterclockwise revolutions then wait until a steady state value has occurred.
9. Enter 60(%) in the Manual (%) dialog box. Wait approximately 10 minutes then stop the VI run.
10. Load the data into the first five columns in an MS Excel spreadsheet as shown in Figure 2. ( Extract only the data that pertains to the step change in control signal.)

	A	B	C	D	E	F	G	H
1			Start Time	460				
2								
3		Parameters	Ho	8		RMS	0.0709987	
4			Hss	21.99243108				
5			tau	572.3388326				
6			delay	15				
7								
8	Time(s)	V In (v)	Control Sig(%)	Height (in)	Setpoint (in)	Shifted Time	H pred	err^2
9	437	3.93	45	7.91	2	-38	8	0.0081
10	438	3.93	45	7.921	2	-37	8	0.006241
11	439	3.93	45			-36	8	0.003721
12	440	3.93	45			-35	8	0.010404
13	441	3.93	45				8	0.011664
14	442	3.93	45				8	0.002401
15	443	3.93	45				8	0.001936
16	444	3.93	45				8	0.010404
17	445	3.93	45				8	0.015625
18	446	3.93	45				8	0.006241
19	447	3.93	45				8	0.003721

Figure 3.

11. Obtain the calculations for the other entries in the spreadsheet then use SOLVER to minimize the RMS by adjusting the time constant, tau, and the steady state height, Hss. (Since the actual delay time is almost negligible, fix the delay time to 15 seconds so that the Cohen-Coon method can yield reasonable values.)

12. Evaluate the following:

$$K = \frac{H_{ss} - H_o}{u_1 - u_o}$$

$$r = \frac{\text{delay}}{\text{tau}}$$

$$K_c = \frac{1}{K \cdot \text{tau}} \left( 0.9 + \frac{r}{12} \right)$$

$$\tau_I = \text{delay} \cdot \left( \frac{30 + 3r}{9 + 20r} \right)$$

13. Apply the controller settings as follows (a zero for Rate will turn off the derivative mode):

$$\text{Proportional Band} = \frac{100}{K_c}$$

$$\text{Reset Time} = \tau_I$$

14. Switch the AUTO to ON and test the controller by changing the set points.
15. Test the controller by changing turning V12 one or two turns clockwise or counterclockwise.

Table 1.

tau	
Hss	
Ho	
delay	
K	
Kc	
Proportional Band	
Reset Time	



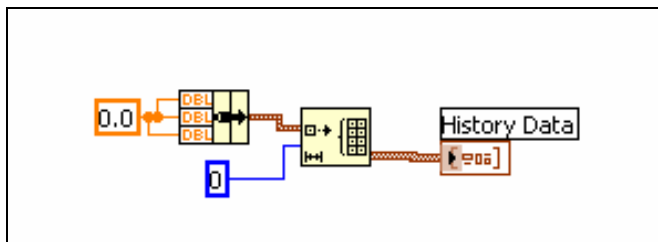


Figure A4. CLEAR DATA sub-VI.

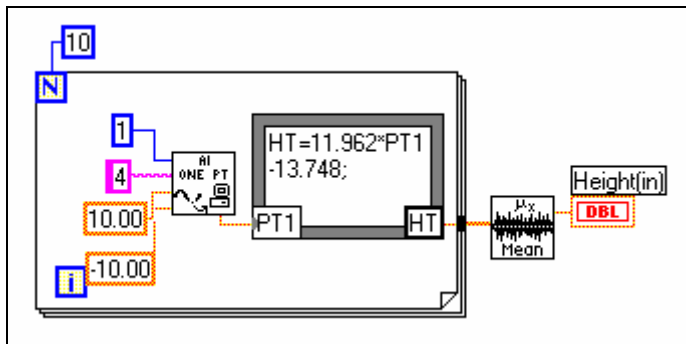


Figure A5. DAQ HT sub-VI

## Appendix B Current Loop Standards and I/P Transmitters

The standard mode for transmission of electrical signal in industrial process control and instrumentation is the analog 4-20 mA current loops. A current loop can be converted to a voltage input with a precision resistor, such as the case in some data logging instruments.

The key advantage for using current measurements is that the accuracy of the signal is not affected by voltage changes due to wire resistance or the transmission noises. The 4 mA reading is known as the “live-zero”. This allows the system to detect failures in the current loop, i.e. when the current signal transmitted is 0 mA to less than 4mA, a failure could be flagged.

Around the 1940s, the standard mode for signal transmission is the 3-15 psi pneumatic signal. The change to the 4-20mA analogue signal standard was introduced around the 1960s. These standards are slowly being replaced by the “field-bus” standard which take advantage of smart-sensors and digital transmission of data. However, the standard is still being debated. Until the new standard has been established, several instruments will continue to be based on the 4-20 mA standard as well as the 3-15 psi standard.

A transducer called the Current/Pressure Transmitter is used to convert the current signal in mA to pressure signals in psi. The pressure signal will then be sent to move the position the control valve.

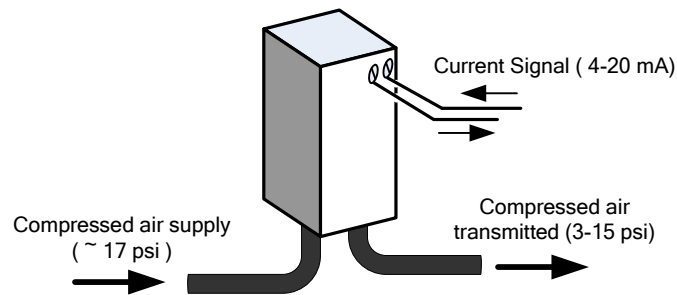


Figure B1. Current to Pressure Transmitter.