

Experiment 6: Feedback Control 1

(tbc 3/22/2007, revised 3/25/07,3/30/08)

Objective: To implement a feedback proportional control system to control temperature.

I. Introduction: Feedback Control of an Electric Lamp Temperature

Using the temperature measurement of the lamp, T_m , we compare it with a desired set-point temperature: T_{set} . The difference between these two signals is the error signal defined as, $e = T_{set} - T_m$. The error signal is then processed using a control law to evaluate a control signal (or decision), u . The value of u is sent to an actuator which determines the control action, z . In our case, z is the electrical energy that is supplied to the lamp.

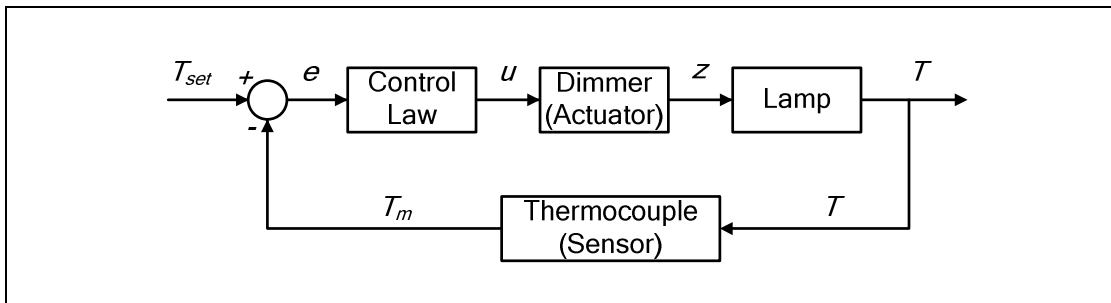


Figure 1.

For this experiment, we will implement a simple proportional control law: $u = u_0 + K_c(T_{set} - T)$, where u_0 is the bias control signal and K_c is the proportional gain.

II. Experimental Setup

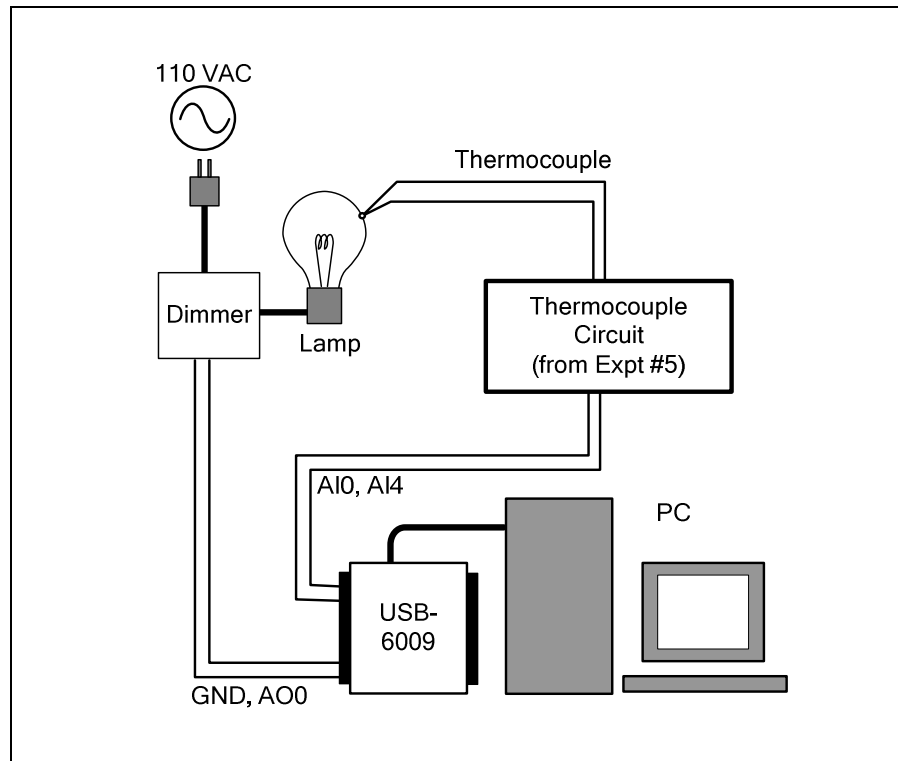


Figure 2.

III. Procedure/ Tasks:

1. Create a “Thermocouple” sub-VI. (See Appendix A)
2. Create a “Dimmer sub-VI”. (See Appendix B)
3. Create a “Proportional Controller sub-VI. (See Appendix C)
4. Start a new VI. Combine the above sub-VIs. To access the sub-VIs created, go to “Functions palette”, **[Select a VI...]** subitem.
5. Add a “Setpoint” slider control, “Proportional Gain” knob control, “Temperature” chart and “Control Signal Chart”, as shown in the “Proportional Feedback Control VI” in Figure 3a. **[Right-click]** on the slider block (in the front panel) and select **[Visible Items]→[Digital Display]**. Reposition the **[Digital Display]** to be below the slider as shown in Figure 3a. Do the same with the “Proportional Gain” knob control.
6. Set the gain to 0.1, 1.0 and 5.0. Observe the temperature response in terms of steady state offset error, as well as the control signal behavior (see Table 1).

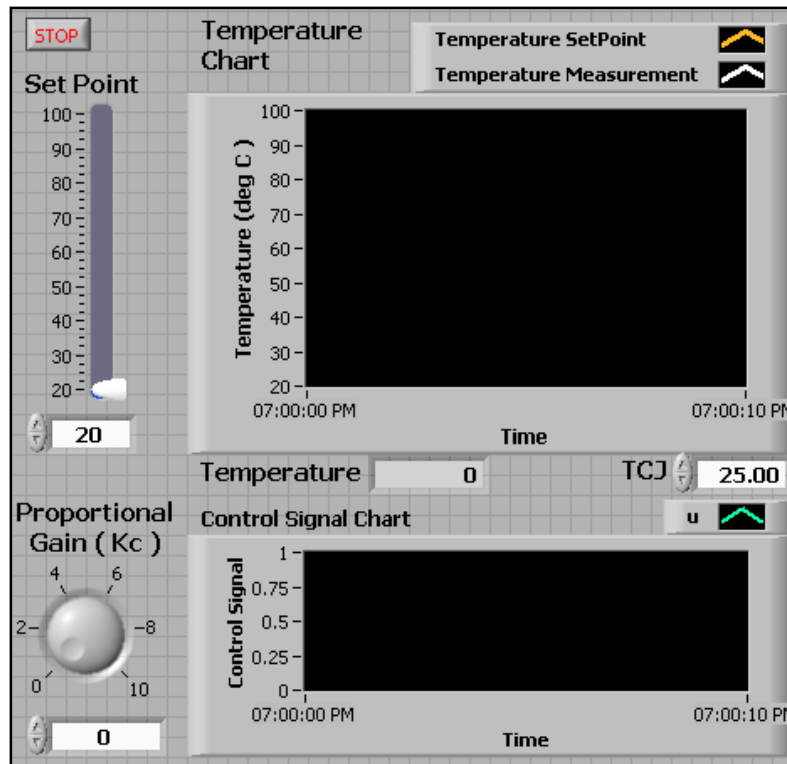


Figure 3a.

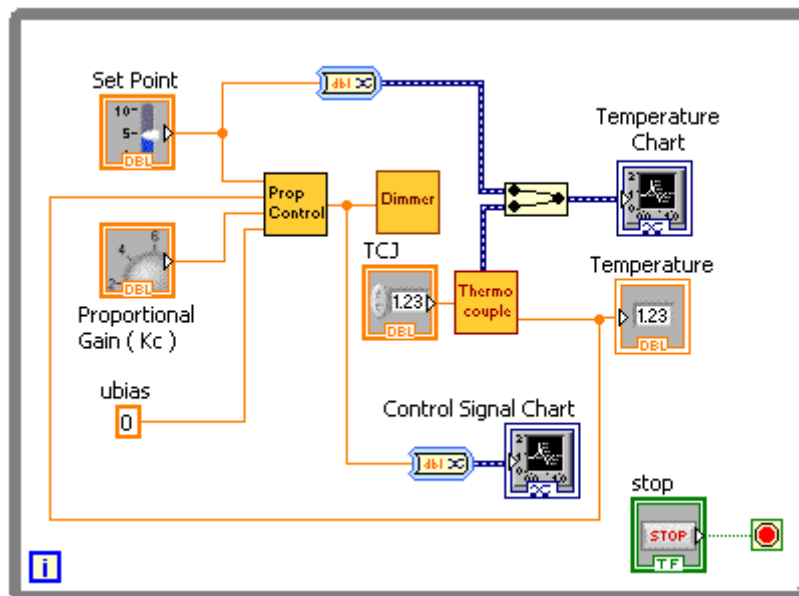


Figure 3b.

Observation:

Gain: 0.1

<p>Temperature Response:</p> <p>Control Signal Response:</p>

Gain: 1.0

<p>Temperature Response:</p> <p>Control Signal Response:</p>

Gain: 5.0

Temperature Response:

Control Signal Response:

Other Notes and Comments:

Appendix A. Creating a Thermocouple Sub-VI

- Open the “Thermocouple” VI (from experiment 5).
- Delete the “Gain” and “Offset” numeric control blocks and the “Vm” indicators. Press **[CTRL-B]** to remove broken wires. Hover the cursor around the **G** input node then right-click and select **[Create]→[Constant]**. Do the same with the **Offset** input node (See Figure A1.) Enter the values found in experiment 5.
- Select all the blocks (in the block diagram window) except for “STOP functions” and “Elapsed Time functions”.

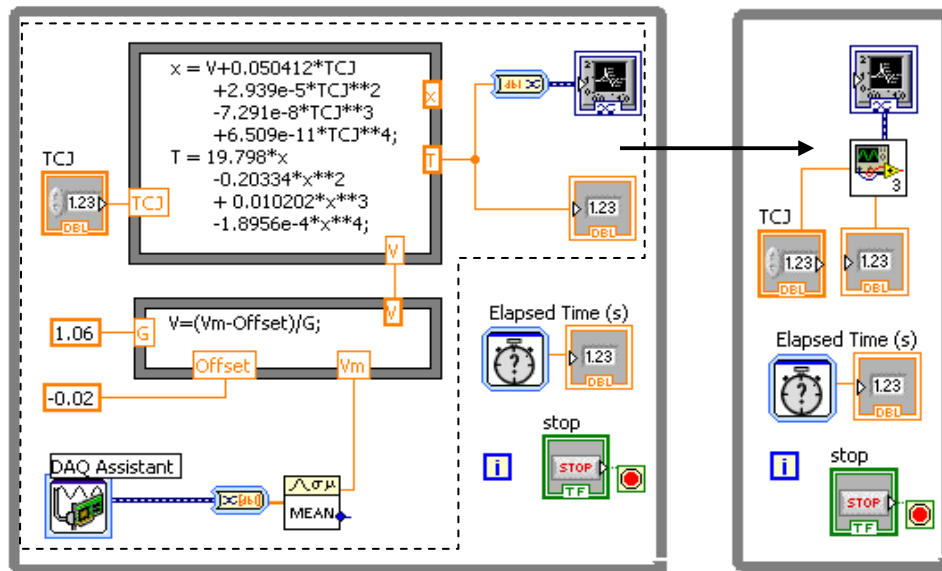


Figure A1. Replacing a group into a sub-VI.

- In the block diagram window, select the **[Edit]→[Create subVI]** menu item. A small icon should appear to replace the group of blocks into a sub-VI. (see Figure A1.)
- [Double-Click]** the sub-VI icon. The sub-VI window should pop-out. It is suggested that you change the icon by **[Right-Click]**-ing the icon located at the top-right corner of the sub-VI window then select the **[Edit Icon]** option (see Figure A.2). Once the icon has been modified, select **[File]→[Save As]** to save a copy of the sub-VI. (We will refer later to this sub-VI as the “Thermocouple subVI”.)
- Close all VIs (select **[Don't Save]** to preserve a copy of the original Thermocouple VI).



Figure A2. Suggested change of icon.

Appendix B. Creating a Dimmer Sub-VI

1. Create a new VI as shown in Figure B1.

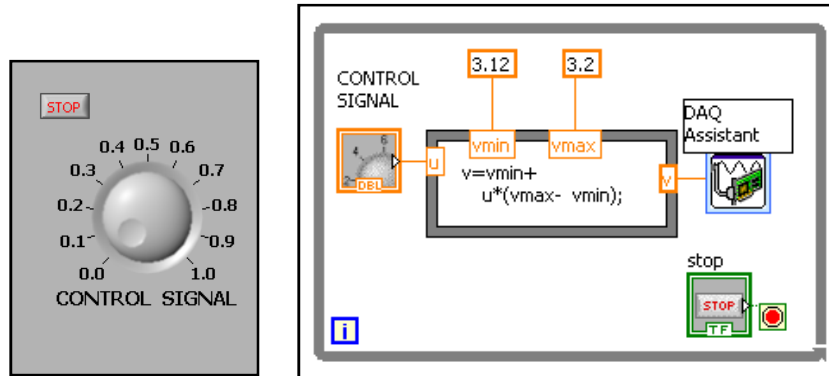


Figure B1.

where the “DAQ Assistant” is obtained from the Functions Palette, **[Express]→[Output]** icon menu. When the DAQ Assistant window pops out, select **[Analog Output]→[Voltage]→[ao0]**, then click **[Finish]**. The properties window should pop out next. Accept the default settings by clicking **[OK]**.

2. Run the VI. If necessary, stop the run and adjust the values of “**vmin**” and “**vmax**” such that the lamp is off when the “Control Signal” is zero and that the lamp is fully on when the “Control Signal” is 1.
3. Reduce the VI to a subVI . Then **[Double-CLICK]** on the subVI to edit the icon as was done in Appendix A. (see Figure B2.)

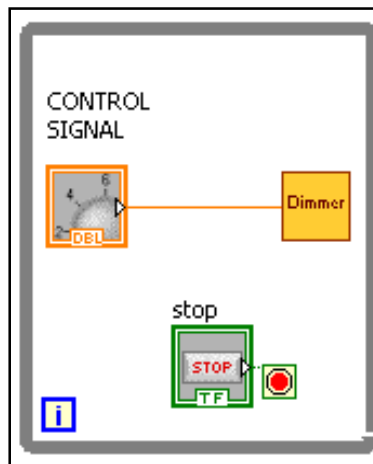


Figure B2.

4. Close all files. Save the VI and the subVI as “Dimmer” and “Dimmer (SubVI)”, respectively.

Appendix C. Creating the Proportional Feedback Control Sub-VI

1. Create a new VI shown in Figure C1.

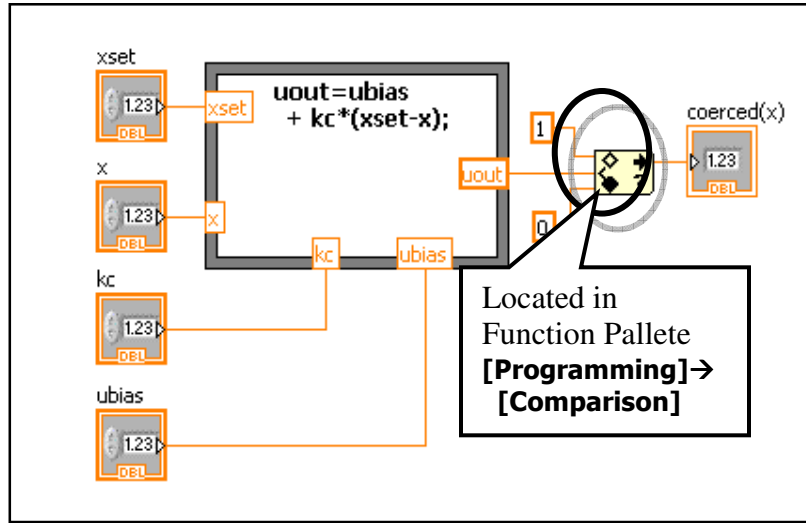


Figure C1.

2. Reduce to subVI and edit icon (see Figure C2).

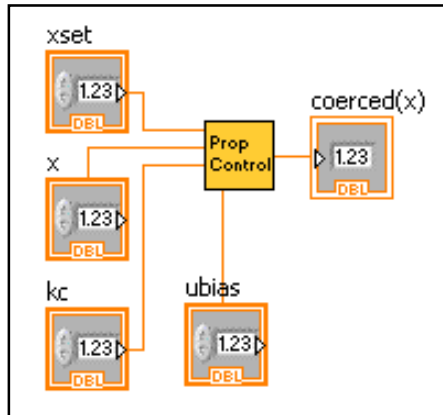


Figure C2.

3. Close all files and save the subVI as “Proportional Feedback Controller(SubVI)”.