Sfwr Eng/TRON 3DX4, Lab 3

Introduction to Data Acquisition

First lab Week of: Feb 24, 2014
Demo Due Week of: End of Lab Period, Mar. 3, 2014
Assignment #3 posted: Thu Feb. 27, 2014

Announcements:

This lab has only a demonstration portion. To get your demonstration marks, every time the lab asks you to "show your work/output to your TA", show your TA that portion of the lab, fully working.

Goals:

1. Introduction to basic elements of a PC based data acquisition system
2. Learn how different hardware/software components work together for data acquisition
3. Create a VI to measure temperature from a thermocouple
4. Measure the rotation of a Quadrature Encoder

Note 1: This lab consists of five (5) in-lab activities. Marks allocated to each are indicated in square brackets.
Note 2: Most of the information given below is based on various documents available on the web site of National Instruments (www.ni.com), however the information given in those documents is more general in the sense that it covers all of the related NI products. We have extracted the information that is specific to the products used in our labs. Use this information to concentrate on specific devices while reading the detailed NI documents referenced here.

PC-based data acquisition system (DAQ)

- A PC-based DAQ system consists of:

  Signals generated by transducers and sensors: The signals that are to be acquired or generated by DAQ system

  Signal conditioning hardware: To adjust the level of an available signal, to reduces noise or to excite a sensor. This hardware is often a part of the DAQ hardware.

  DAQ hardware: Serves as an interface between a PC and the outside world. Its primary purpose is to convert analog signals to digital form for interpretation by PC.

Measurement services software: A software layer between the hardware and the application software. It should provide configuration and installation services, a programming interface, self-calibration, and other features to simplify the interface with DAQ hardware.

Application software: A program developed using a standard programming environment such as LabView.

- NI produces several hardware platforms for data acquisition that include devices for PCI bus, PCMCIA bus, PCI express, PXI and USB etc.
- In our labs, we use DAQCard-6035E or 6221 that is installed inside the PC in a suitable slot.
- The DAQCard is connected to a BNC-2120 CONNECTOR ACCESSORY FOR E SERIES DEVICES via a 68 core cable.
- BNC-2120, apart from several connectors, has a function generator with a frequency-adjustable, TTL-compatible square wave, and a frequency- and amplitude-adjustable sine wave or triangular wave. It also has a quadrature encoder. It can be used to demonstrate and test the use of analog, digital and counter/timer functions of DAQ device.
- **Before you go for your lab session, please read the following NI documents at your own convenient time:**
  - "Intoduction to data acquisition" an on-line tutorial
    http://zone.ni.com/devzone/cda/tut/p/id/3536
  - "DAQCard User Manual"
    http://www.ni.com/pdf/manuals/370503k.pdf or 371022k.pdf
  - "BNC-2120 Connector accessory for E series devices"
    http://www.ni.com/pdf/manuals/372123c.pdf
  - Quadrature Encoder Measurements: How-To Guide
    http://zone.ni.com/devzone/cda/tut/p/id/7109
    http://zone.ni.com/devzone/cda/tut/p/id/4763

Activities in the lab

1. **Configure the DAQ device:** [10]
   NI uses NI-DAQmx to communicate with data acquisition devices. It provides a tool, "Measurements and Automation Explorer (MAX)" to configure NI hardware and software.
   - Launch MAX
     This can be done directly by clicking **ALL Programs - National Instruments - Measurement and Automation** or by double clicking

MAX icon on your desktop or if LabView software is running, by going to **Tools - Measurement and Automation Explorer** on the menu bar.

Devices and Interfaces section under "My System" shows all the National Instruments devices installed and configured on your PC. The NI-DAQmx Devices folder shows all the NI-DAQmx compatible devices. By default, the NI "PCI-6035E:Dev1" (On some PCs it may be PCI-6221) shows up.

- Right-click on the above device and click on Self-Test. The device passes the self test, which means it is configured properly and ready to be used in your LabVIEW application.
- *Show the output to your TA.*

2. **Create and Configure a Task:** [15]
   The purpose of this activity is to demonstrate measurement of temperature using the **Temperature Sensor** on the top left corner of the BNC-2120. This sensor provides a voltage signal proportional to the temperature it senses. Note that it is not the same as measurement of temperature using a thermocouple.

   - **Launch Labview.** Open a new VI and place "DAQ Assistant Express VI" from the *express/input* functions palette, on the block diagram. This should result in **Create New** dialog box. Under **Acquire Signals** click on **Analog Input** and then select **Voltage**.
   - The dialog box displays a list of supported physical channels based on the devices installed.
   - In the supported physical channels list, select **ai0** and click **Finish** button. This opens another dialog box displaying options for configuring the selected channel.
   - On the **Settings** page, enter 1 for the Max and 0 for the Min value
   - In the **Timing Settings** section, select **Continuous Samples** from the **Acquisition Mode** menu and enter a value of 1000 in the **Samples to Read** box.
   - Select **Differential** for the Terminal Configuration.
   - Under **Custom Scaling - Create New - Map Ranges**. Give a suitable name such as VoltageToTemp to your scale.
   - Under "Pre-scaled" enter 1 for Max and 0 for Min.
   - Under the "Scaled" enter 100 for Max and 0 for Min.
   - In the box titled "Scaled" enter "DegC".
   - The reason for the above scaling is that the temperature sensor in BNC-2120 outputs a voltage between 0 and 1 and you want to scale it to show temperature in Degrees Centigrade between 0 and 100.

- Close the NI-DAQmx Scale Configuration window by selecting the 'OK' button and return to the previous DAQ Assistant Configuration window. Notice that in the "Voltage Input Setup" area the "Scaled Units" has changed to 'DegC'. Now change the "Signal Input Range" as Min:0, Max:100 (Software does not change it automatically so you need to do it manually!)
- Close the Configuration Window by selecting the 'OK' button to return to Labview block diagram.
- Labview automatically generated code for you. Click **Yes** to automatically generate the "While Loop" and a "Stop Button".
- Connect a "Graph Indicator" to the **Data** terminal output of the "DAQ Assistant Express VI".
- Run the VI, touch the "Temperature Sensor" on BNC-2120 with your finger and observe the change in the output graph. (Make sure the selector switch on the BNC-2120 connector is in position *temp* and the switch under the channel is in position *GS*.)
- *Show the output and the block diagram of your VI to your TA before proceeding further.*
- Save your VI as lab3-2.vi

3. **Add a Thermometer:** [15]
   Instead of using a graph indicator to view the change in temperature, replace it with a numeric thermometer.

   - Open your lab3-2.vi.
   - Right click on the graph indicator in the front panel and select **Replace**. Then select **Modern - Numeric - Thermometer** from the control palette that appears. The thermometer should replace the graph indicator.
   - Also replace the **Stop (F)** button with **Stop (Boolean)** button.
   - Modify the thermometer indicator by right-clicking it and selecting Properties. On the Appearance Tab, change the Label to Temperature.
   - On the Scale tab, change the Minimum to 20 and the Maximum to 30. Click Ok when you are done.
   - To perform analysis on your data, select the **Express - Signal Analysis - Statistics Express VI** and place it on your block diagram.
   - A properties window will appear. Make the following selections and click OK.
     - Statistical Calculations: Arithmetic Mean
     - Extreme Values: Maximum, Minimum

- Connect the data output of the DAQ Assistant VI to the Signals input of the Statistics VI.
- Right-click the "Arithmetic Mean" output of the "Statistics VI" and select **Create - Numeric Indicator**. This will create a numeric indicator on the front panel that will display the mean. Repeat this step for both the "Maximum" and "Minimum" outputs of the "Statistics VI".
- Switch to the front panel and rearrange your controls and indicators if necessary. The front panel should look like that shown in figure 1.

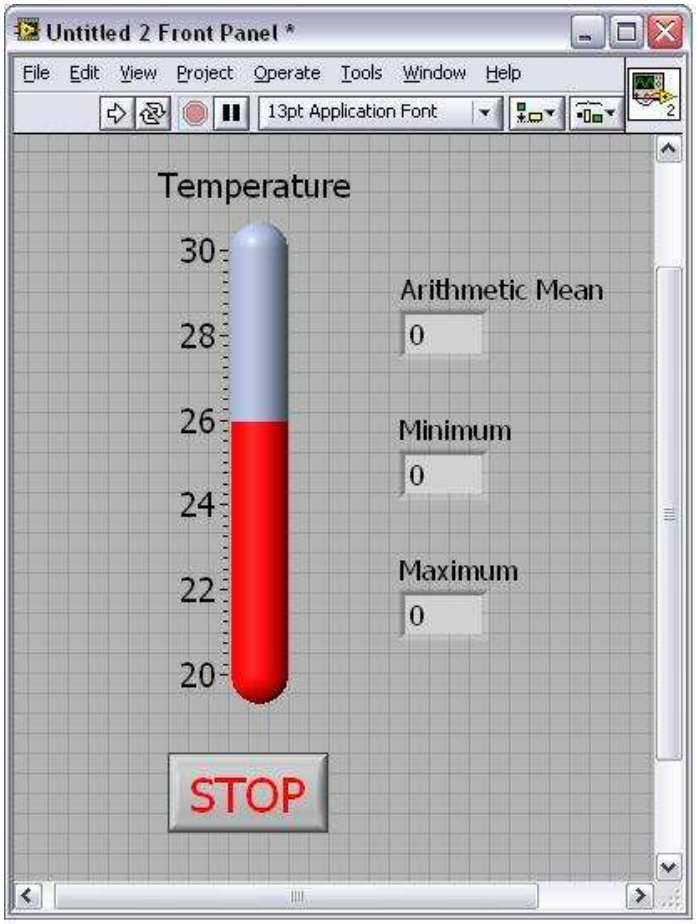

Figure 1:

- Run the VI, touch the "Temperature Sensor" on BNC-2120 with your finger and observe the change in the output of thermometer.
- If you are not seeing enough of a temperature fluctuation, stop the VI and decrease the range on your thermometer indicator.
- *Show the output and the block diagram of your VI to your TA before proceeding further.*
- Save your VI as lab3-3.vi

4. **Measure the rotation of a Quadrature Encoder using BNC-2120:** [15]

   - If you have not already done so, please read Quadrature Encoder Measurements: How-To Guide
     http://zone.ni.com/devzone/cda/tut/p/id/7109
     http://zone.ni.com/devzone/cda/tut/p/id/4763

   - Also read "Quadrature Encoder" section of the BNC-2120 manual
   - Download BNC 2120 Quadrature Encoder vi named *QuadratureEncoder.vi* from the labs/Data folder on the course web page.
   - Configure the VI to work with your board. (If necessary change the appearance of the dial indicator)
   - Make sure the encoder connections are properly wired.
   - Run the VI and *show results to your TA.*
   - Save your VI as lab3-4.vi.

5. **Modify lab3-4.vi**[25]

   - Modify the BNC-2120 Encoder instrument to add an "angular odometer", i.e. a readout of the total angular distance traveled by the knob (regardless of direction) since the time the VI was last restarted.
   - This requires you to set up shift registers that hold the values at the end of a loop (for / while) iteration for use in the next iteration.
   - Go to *LabView Help→Search the LabView Help→shift registers*, and familiarize yourself with shift registers. What they are and how to create them.
   - Set the initial value of the shift registers to zero.
   - Control the timing of the while loop by adding a "Wait Until Next ms Multiple" (Reference Help as before).
   - Add the current value of the angle θ to the previous value stored in the shift register and connect the output to the "angular odometer".
   - Hint: You'll need two shift registers in total to implement the "angular odometer".
   - Run the VI and *show results to your TA.*
   - Save your VI as lab3-5.vi