Session 2559

Data Acquisition Laboratory

Asad Yousuf
Savannah State University

Abstract

The essential element to automate your system for data collection and analysis is termed as the data acquisition. The data acquisition system is the process of making measurement of physical event and storing them in some logical fashion. Having a formal background in engineering or science is helpful but the best way to learn is by implementing the system with hardware and software components.

The popularity and acceptance of computer-based instrumentation has created a need to provide the students in engineering technology with a training course based on the aforementioned technology. This type of training can be introduced as an integrated required course for all the disciplines of Engineering Technology (Civil, Electronics, Mechanical, and Chemical Engineering Technology). In an effort to introduce the students to this computer-based instrumentation technique, the Department of Engineering Technology at Savannah State University has developed a course titled as Data Acquisition System.

This paper will discuss the course outline, laboratory equipment and an example to illustrate the application of data acquisition system. This paper will also report on the hardware and LabView virtual instrument software developed by National Instruments.

Introduction

Data acquisition system is a required course for all Engineering Technology (Civil, Chemical, Electronics, and Mechanical) majors at Savannah State University. This course is based on the personal computer, along with Data Acquisition (DAQ) cards, BNC-2120 connector accessory for E-series devices and software to create devices called virtual instruments (VI).

Software is just a basic element of a data acquisition system. A typical industrial PC-based DAQ system may consist of components such as; transducers, signal conditioning, plug-in DAQ boards and application software to create virtual instrument. However, for training purposes the BNC 2120, DAQ cards and LabView software are used for acquiring and analyzing the data.

The laboratory-based training is based on the BNC 2120 but the concept of measurement of real world physical signals is also introduced. The fundamental concept is based on the fact that the data acquisition system is centered on a physical quantity, which may be electrical, mechanical, or anything else that needs to be measured. The signal that needs to be measured is converted to a signal that can be easily transmitted and measured by means of device known as a sensor or a transducer, such a device converts the physical signal into an electrical signal, such as voltage or current. In a data acquisition system environment one cannot connect signals directly to a plug-in DAQ board. Typically, the signal must be conditioned before the plug-in DAQ board converts them to a digital signal; such a system is illustrated in figure 1.0. Finally, the software controls the data acquisition system by capturing the data, analyzing, and displaying the results [1].

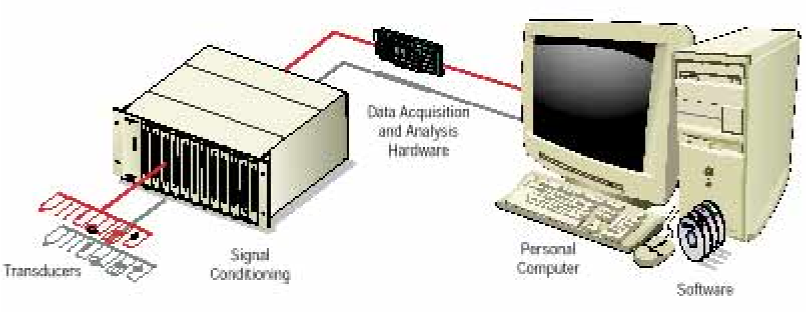

Figure 1.0 Typical DAQ system

Software:

Research shows that the software for data acquisition system is based on programming environments such as Laboratory Virtual Instrument Engineering Workbench (LabVIEW), C, and C++. However, LabVIEW provides the flexibility and widespread functionality available in the C programming, but at the same time offers productivity, which is 5 to 10 times better as compared to C programming language. Many software data acquisition packages are available but LabVIEW is considered as an industry for many data acquisition applications. Based on the popularity of LabVIEW this software package is used in our data acquisition system course to deploy applications [2].

LabVIEW is based on graphical programming language C. The development of a virtual instrument (VI) with LabVIEW consists of a front panel and a block diagram. The front panel is the graphical user interface (GUI) of the VI which may contain switches, knobs, meters, and other type of devices. Drag-and-drop method is used to select controls and indicators to build user interface on the front panel. From the front panel, the user can interact with the applications using controls to change values on switches, knobs, sliders, gauges, and etc. Data can also be displayed on the front panel using graphs, charts, LEDs, etc. The block diagram contains the source code for the virtual instrument. The user can select functions such as file I/O, instrument I/O, or data acquisition, and place them on the block diagram of your VI. The user can connect these functions together with wires like a schematic or a flow chart to define execution of the VI. Figure 2 shows a typical front panel and the block diagram [3].

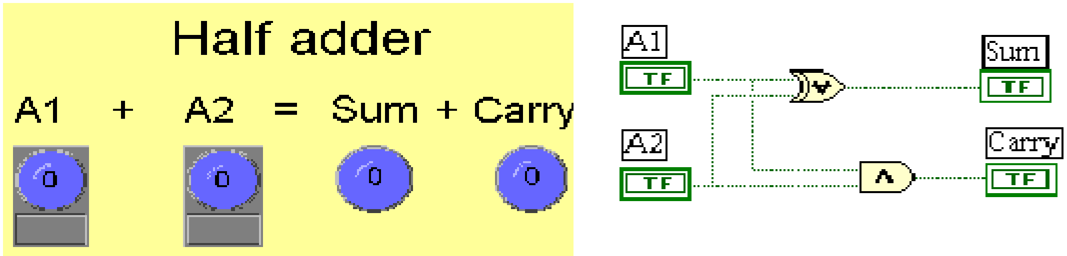

Figure 2.0 Block diagram and Front Panel

In order to facilitate the organization of front panel and block diagram, LabVIEW has graphical floating-point palettes to create virtual instruments. The three main palettes include the tools, control, and function palettes. Tools palette is used for creating, modifying, and debugging virtual instruments. The tools palette consists of operating, labeling, positioning, wiring, color copy tool, and etc. The control palette is used to add controls and indicators to the front panel. Each option in the palette displays a sub palette of available controls and indicators for that selection. The control palette consists of numeric, string, Boolean, list, graph sub-palettes and etc. Function palette is used to build block diagram. Each option in the palette displays a sub-palette of top-level icons. If the functions palette is not visible, you can open the palette by selecting Show Functions Palette from the windows menu. Functions palette may consists of structures, Boolean, numeric, string, file I/O, instrument drivers, select a VI, and etc. Figure 3.0 shows the tools, control, and function palette [4].

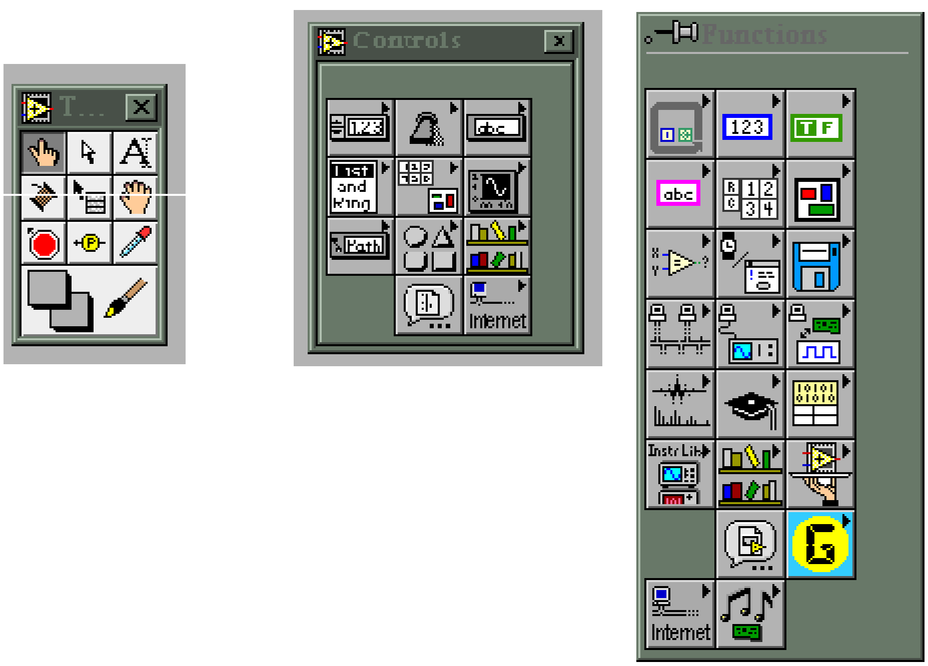

Figure 3.0 Tools, control, and function palette

Course Content

Civil, Chemical, Electronics, and Mechanical Engineering Technology students are introduced to ELET 3701K Data Acquisition Systems course at the junior level. The course is a two-credit hour course consisting of one-hour lecture and a two-hour lab per week. The course covers the fundamentals of data acquisition system and includes laboratory sessions to on instrumentation techniques. Students work in pairs on structured exercises, maintain detailed laboratory logbooks, and write formal reports. Students are exposed to the basic programming concepts and functions of LabVIEW during the entire semester. In addition to using conventional instrumentation, students also use data acquisition to measure: voltage, current, and power in electrical circuits; time constants in transient tests; temperature, pressure, and force using appropriate transducers [5].

As an indication of successful culmination of this course, students should be able to perform the tasks listed below:

- Be able to understand concepts of data acquisition system.
- Have basic understanding of the hardware of data acquisition.
- Create virtual instruments using LabVIEW
- Use data acquisition systems to measure physical quantities.
- Gain good understanding of General Purpose Interface Bus (GPIB) communication devices and drivers.

The following topics are covered during the semester:

1. Introduction to LabVIEW
2. LabVIEW programming
3. Building an application
4. Instrument drivers
5. Writing a DAQ program
6. Process control application
7. Physical application

The following are the laboratory projects that students perform during the semester:

1. Creating a virtual instrument (VI) and sub VI.
2. Use While, For Loops, and a waveform chart for acquiring data in real time.
3. Create a VI that takes a number representing degree Celsius and convert it to a number representing degree Fahrenheit. Also, use thermocouple to monitor the real time temperature.
4. Build a VI that uses the formula node to evaluate a complex mathematical expression and graph the results.
5. Build a VI that illustrated the concept of case structure.

The required book for the course is: LabVIEW graphical programming, Johnson Gary. LabVIEW Basic Programming manual and LabVIEW data acquisition manual from National instrument are used as references[6,7].

Data Acquisition Laboratory

PC-based data acquisition laboratory at Savannah State University is centered around the computer boards hardware and LabVIEW software that provides hands on data acquisition training to the engineering technology students at a junior level. Literature search revealed that LabVIEW software is being used at various institutions and industries. The modularity of LabVIEW software helps the student test ideas before implementing an experiment with the hardware. At present the laboratory is based on the following equipment:

- PC with an Intel 450MHz Pentium II processor w/512k Cache, 128MB SDRAM on Windows NT platform. (10 workstations)
- PCI-MIO-16E-4 Multifunction PCI data acquisition (DAQ) board (10 Workstations)
- BNC 2120 connector accessory for E Series Devices (10 Workstations)
- Thermocouples

PCI-MIO-16E-4 (E Series Multifunction DAQ card):

The NI 6040E (PCI-MIO-16E-4) device use E series technology to deliver high performance and reliable data acquisition capabilities to meet a wide range of applications requirements. You can get up to 500 kS/s single channel, 12-bit performance on 16 single-ended analog inputs. The E series DAQ device feature analog and digital triggering capability, as well as two 24-bit, 20 MHz counter/timers; and 8 digital I/O lines. This E-series is directly interfaced to the BNC-2120 connector.

BNC-2120 Connector Accessory:

BNC-2120 is a shielded connector block with signal-labeled BNC connector for easy connectivity to analog input, analog output, digital I/O and counter/timer signals to the E-series device. The BNC-2120 also provides a function generator, quadrature encoder, temperature reference, thermocouple connector and LED so that the user can test functionality of the hardware. The BNC-2120 has the following characteristics:

- 8 BNC connectors for analog input
- 2 BNC connectors for analog output
- 68-pin input/output connector that connects directly to the E-series device
- 2 user-defined BNC connectors
- A function generator with a square wave, sine-wave or triangle wave

Figure 4.0 shows the BNC-2120 front panel [8].

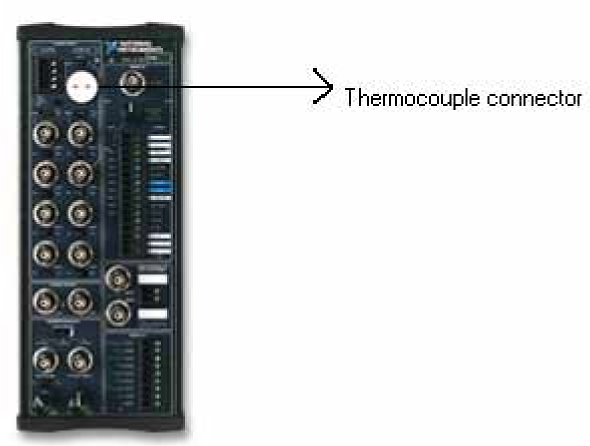

Figure 4.0 BNC-2120 Front Panel

Example:

The following paragraphs will discuss a temperature measurement lab with thermocouples. Students are required to do the following steps for this lab exercise:

- Connect the BNC-2120 to the data acquisition card
- Connect the thermocouple to the thermocouple connector
- Create a virtual channel in Measurement and Automation Explorer for a J-type thermocouple. The name of the thermocouple is what will be used as the channel name in the VI in LabView.
- Write a VI to convert Centigrade to Fahrenheit

Figure 5.0 shows the virtual instrument for temperature measurement lab. Temperature signal is displayed on the computer in the following sequence:

1. The thermocouple puts out an analog voltage that is proportional to temperature.
2. The data acquisition card digitizes this signal.
3. This information is then passed onto the Measurement and Automation Explorer software that performs a conversion of the digital voltage level to a real world temperature.
4. This value is displayed in the LabView program.

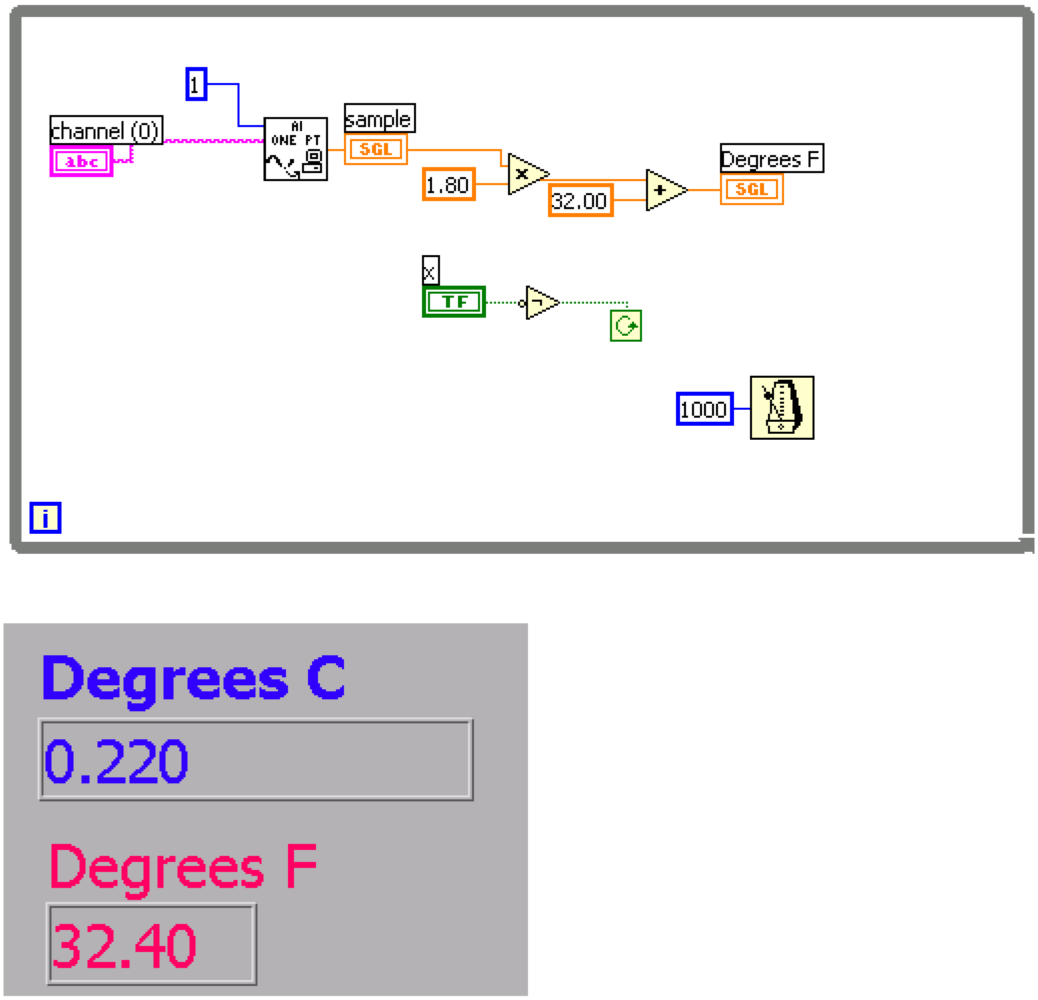

Figure 5.0 Block diagram and front panel for temperature measurement

Summary:

This paper presented a brief discussion about the data acquisition course offered at Savannah State University. The training introduces students to the techniques for interfacing the basic measurement and instrumentation circuitry and systems to monitor physical characteristics. The data acquisition laboratory provides the necessary hands-on PC-based instrumentation training, which is highly desirable in industry. The author would like to acknowledge, Mr. Kyle Ulrich, sales engineer at National Instruments for helping us implement the data acquisition laboratory at Savannah State University.

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ASAD YOUSUF
Asad Yousuf is a Professor of Electronics Engineering Technology at Savannah State University. He received his BS in Electrical Engineering from the NED Engineering University, Karachi, Pakistan in 1980 and MS in Electrical Engineering from the University of Cincinnati in 1982 and an EdD from the University of Georgia in 1999. Asad is a registered Professional Engineer in Georgia. He is also a Microsoft Certified System Engineer (MCSE).