Using LabVIEW in Instrumentation and Control Course

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Abstract

Computer data acquisition and processing have been widely used in researches and industrial controls, because of high sampling speed and being able to interface with other instruments. To keep students abreast with the new technology, software and hardware for data acquisition and processing are used in our instrumentation and control course.

The software and hardware used are LabVIEW and PCI-1200 board from National Instruments. LabVIEW is a graphical programming language that has been widely adopted throughout industry, academia, and government labs as the standard for data acquisition and instrument control software. PCI-1200 board is a low-cost, multifunction I/O Data acquisition card that communicates with a PC through a parallel port. In our laboratory, they are used for measuring temperatures, stress and other variables. With LabVIEW, PCI-1200 board, and signal conditional circuits, students may collect, display, and process the values of those quickly changing variables. They may also see the variations of these variables in detail, which usually is impossible without a digital storage oscilloscope.

Introduction

Data collection is a very common practice in scientific and industrial measurements and controls. Today, many computer data acquisition application packages are available. They offer many benefits over hand-held meters and other traditional measuring instruments. These benefits include measurement automation, data storage and display, and fast sample speed. It is also an advantage to have the measurement results stored in computer memory, so that subsequent analysis of the data can be performed. With data acquisition software and signal converting/conditioning circuits, a computer may measure different physical quantities. Compared to traditional measuring equipment, this may reduce the overall equipment cost.

One of the popular computer data acquisition application packages is Laboratory Virtual Instrument Engineering Workbench (LabVIEW) developed by National Instruments. LabVlEW is a graphical software system for developing high performance scientific and engineering applications. LabVIEW can acquire data and control devices via a data acquisition board, such as the PCI-1200 data acquisition board. LabVIEW, much like the Visual Basic and C^{++} programming packages, includes programming capability and a user friendly interface. LabVIEW has been used by many industries and scientific researchers. One application was developing methods to cool and trap atoms with laser light completed by Dr. William Phillips[1], who is a physicist and fellow with National Institute of Standards and Technology. This research won Dr.

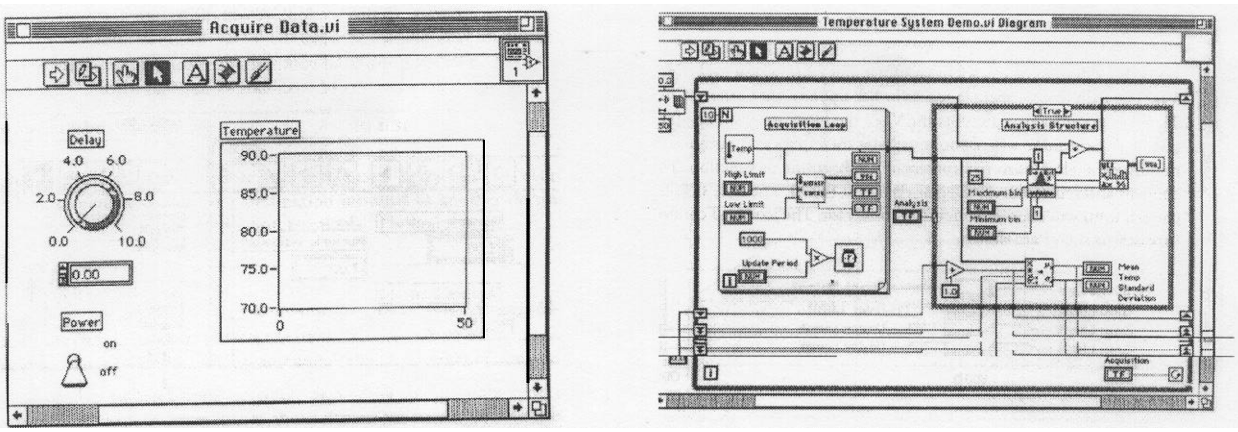
Phillips the 1997 Nobel Prize in physics. In his research, Dr. Phillips used LabVlEW to control atom-cooling experiment.

LabVIEW[2]

LabVIEW is based on the graphical programming language G. A person can use LabVIEW with little programming experience. LabVlEW uses terminology, icons, and ideas familiar to technicians, scientists, and engineers. It relies on graphical symbols rather than textual language to describe functions.

All LabVIEW programs, or virtual instruments (VIs) as they are called, have a front panel and a block diagram. The front panel is a graphical interface of controls and indicators in the form of switches, push buttons, lights, charts, graphs, meters, gauges, tanks, thermometers, and many other useful devices. The front panel, like other Windows based programs, allows the user to adjust controls and make selections with the mouse and pop-up menus.

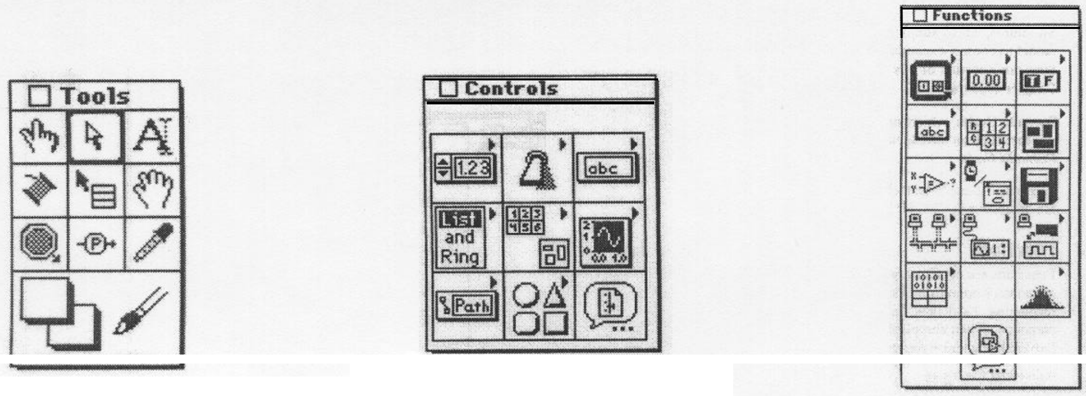
The block diagram consists of icons connected by lines representing electrical wires. The icons replace conventional text-based code. The icons range from simple arithmetic functions to more complex data acquisition and analysis routines. The icons can also consist of input and output operations which may store data to or retrieve data from the computer hard drive. Figure 1 shows a front panel and a block diagram



(a) Front Panel (b) Block Diagram

Figure 1: A front panel and a block diagram

There are several other features in LabVIEW that should be mentioned. They include the Tools palette, the Controls palette, the Functions palette, wiring connections, and debugging. Figure 2 shows the Tools palette, the Controls palette, and the Functions palette.



(a) Tools Palette (b) Controls Palette (c) Functions Palette

Figure 2: LabVIEW's Palettes

The Tools palette contains the tools for editing and debugging front panels and block diagrams. In the Tools palette, there is also a pointing device, which allows the user to begin operation, flip switches, and edit numeric values. This pointing device is also used in the operation of a VI.

The Controls palette is used only with the front panel. It has the controls and indicators used to design the front panel and to create a user interface. The Controls palette also has many types of waveform charts and graphs which allow the user to view measurements in waveform as they would on an oscilloscope.

The Functions palette is used only with the block diagrams. These function routines are used for programming VIs. In the Functions palette, there are arithmetic operation icons, programming structure function icons, and input and output icons.

There are several different wire types in LabVIEW. These wire types are differentiated by their graphical representation. Thickness, color, and shape of the wires will vary depending on the type of data flow conducted. That is automatically indicated by iconic functions.

Incorrect wire connections and other problems will show up as errors in the Error window, after a user tries to run a VI that has such errors. The Error window helps the user to find the error sources by highlighting the problem area and giving possible reasons for the errors.

Measuring temperature with LabVIEW

Figure 3 shows the circuit used to measure temperature in our Instrumentation and Control Lab. The transistor is used as a temperature sensor. When temperature surrounding the transistor varies, the voltage across the PN junction in the transistor will change. This tiny voltage change is amplified by two Op-Amp amplifiers. The total voltage gain and the output voltage range can be adjusted by turning the two 50K potentiometers. The output voltage of the circuit, which reflects the temperature sensed by the transistor, can be monitored with a digital voltmeter. However, the long term voltage variation versus time may not be recorded even with a digital storage oscilloscope.

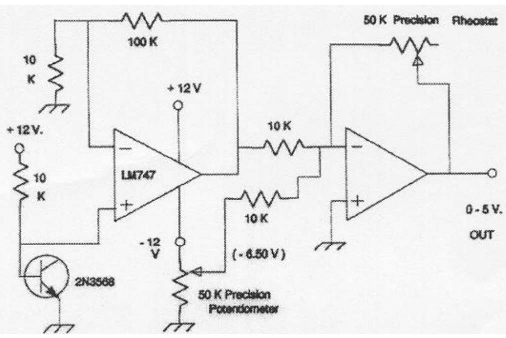


Figure 3: Circuit for temperature measurement

With the LabVIEW and a PCI-1200 data acquisition board, the output voltage of the circuit in Figure 3 can be measured and stored. With proper calibration, done by programming the software, the actual temperature can be easily displayed. Figure 4 shows the block diagram of a VI for measuring temperature. An example of the measured temperature variation versus time is given in Figure 5.

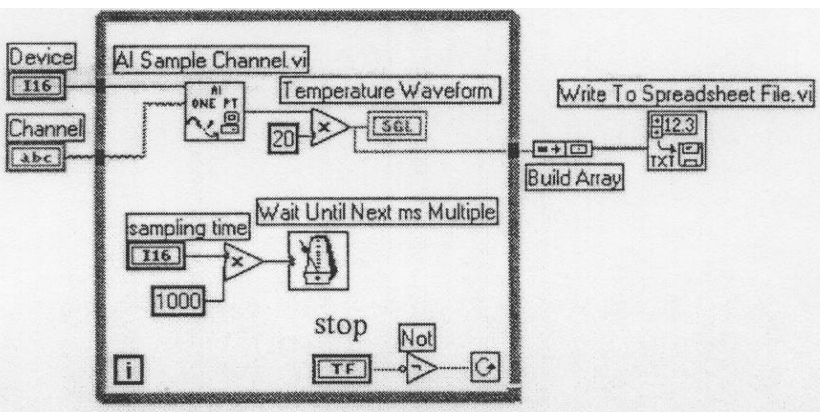


Figure 4: Block diagram for temperature measurement

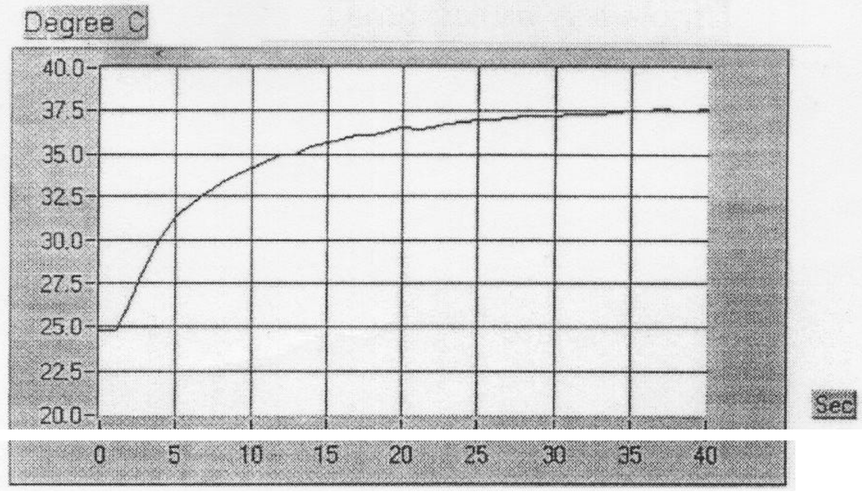


Figure 5: Temperature Variation

Since LabVIEW and the PCI-1200 data acquisition board have variable high voltage gain set up by the programmer, they can be used to measure a signal voltage as low as a few millivolts. The temperature variations sensed by the transistor in Figure 3 were measured without the two Op-Amp amplifiers. With the high voltage gain of the software and hardware, results similar to those shown in Figure 5 were obtained.

Measuring dynamic stress with LabVIEW

Another project, developed in our lab to make use of LabVIEW, was that of measuring dynamic stress. Figure 6 shows the sensing circuit for stress measurement. A strain gage, applied to a cantilever beam, is in one branch of the Wheatstore bridge. The change in the strain gage's resistance affects the circuit's output voltage, which is monitored by a VI. Figure 7 shows the block diagram of the stress measurement and analysis VI. When a weight was added to the end of the cantilever beam. it caused the beam to vibrate. The stress variation in the beam was recorded by the VI and displayed in Figure 8.

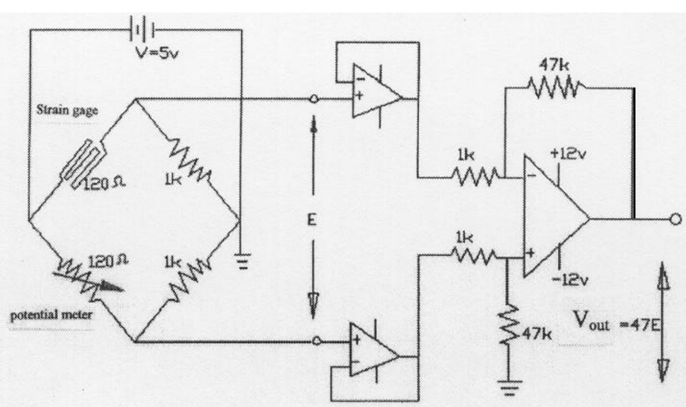


Figure 6: Circuit for stress measurement

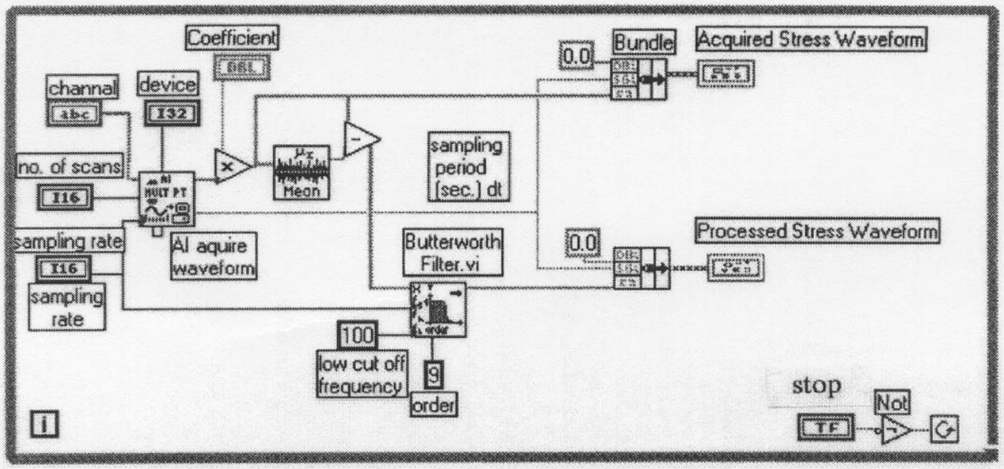


Figure 7: Block diagram for stress measurement

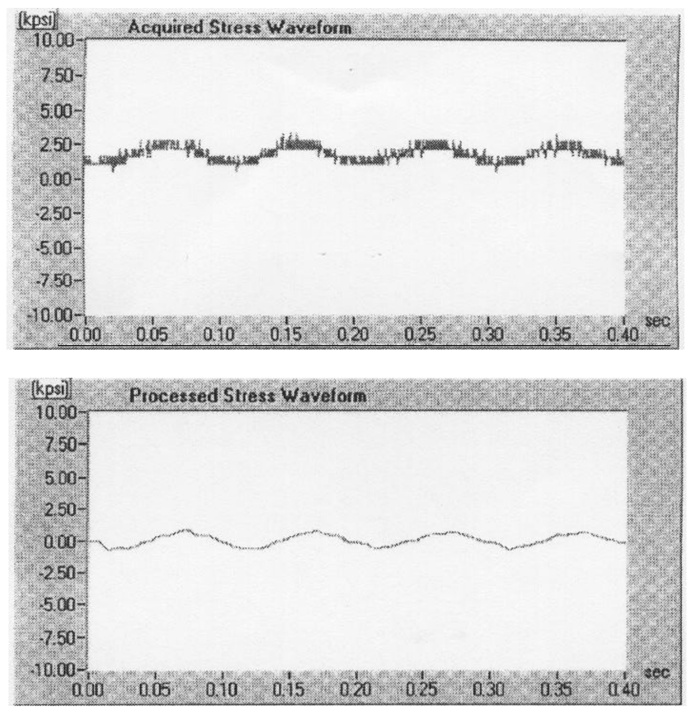


Figure 8: Stress Variation

Conclusions

LabVIEW is very good software for teaching an instrumentation and control course. With LabVIEW, students get an opportunity to make use of the data acquisition software used in scientific and industrial environments and to study its applications.

References

1. Business Wire, November 7, 1997.
2. National Instruments: "LabVIEW User Manual", 1996.

Biography

Dr. Chong Chen is an associate professor in the Department of Engineering Technology and Industrial Studies, Middle Tennessee State University. He received B.S. degree from Hebei Institute of Technology in China, M.S. degree from Tianjin University in China, and Ph.D. degree from University of Kentucky, all in Electrical Engineering. Dr. Chen teaches electric circuits, electronics, controls, and industrial electricity. His research areas include controls, power electronics, electric machines, and electromagnetic fields. Dr. Chen is a Professional Engineer registered in the State of Tennessee.