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ABSTRACT

A course was developed at Austin Peay State University (Tennessee) which offered an opportunity for hands-on experience with the essential components of modern analytical instruments. The course aimed to provide college students with the skills necessary to construct a simple model instrument, including the design and fabrication of electronic circuits and computer programming in a data acquisition (DAQ) language. LabVIEW was selected as the DAQ language for the course. The course covers: introductory concepts of electronic circuit design; fundamental concepts of data acquisition programming using LabVIEW; Waveform generation and acquisition for electrochemistry virtual instrument (VI); and computer-controlled electrochemistry instrument VI. Assignments and recent developments in the course are noted. (AEF)

Data Acquisition Programming (LabVIEW): An Aid to Teaching Instrumental Analytical Chemistry

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ABSTRACT: Chemists often setup, troubleshoot, repair and construct the instruments they use in measurements. For a student, the first experience in "looking under the hood" of an analytical instrument can be quite intimidating. To overcome this fear of the unknown, a course offering an opportunity for hands-on experience with the essential components of modern instruments has been developed. The objective of the course is to provide students with the skills necessary to construct a simple model instrument. Central to these activities is the data acquisition language LabVIEW (National Instruments, Austin, TX).

Data Acquisition Programming (LabVIEW): An Aid to Teaching Instrumental Analytical Chemistry

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Chemists often setup, troubleshoot, repair and construct the instruments they use in measurements. For a student, the first experience in "looking under the hood" of an analytical instrument can be quite intimidating. To overcome this fear of the unknown an opportunity for hands-on experience with the essential components of modern instruments is offered in the Advanced Instrumental Methods course at Austin Peay State University. By seeing how these parts fit into the overall scheme of an instrument, the student can better formulate strategies to test and correct malfunctioning equipment, to modify instruments for a particular purpose, or to construct an instrument not commercially available.

The primary objective of the course is to provide students with the skills necessary to construct a simple model instrument. These skills include the design and fabrication of electronic circuits and computer programming in a data acquisition (DAQ) language. LabVIEW (National Instruments, Austin, TX) was selected as the DAQ language for the course. As seen in the outline provided in Table 1, the course integrates many different subject areas such as: electronics, programming, and electrochemistry. Any of these areas considered separately would be too narrow for an undergraduate course, but as a unit they provide the tools necessary for understanding instrument design.

Table 1. Course Outline (One Semester, Four Credit Hours)

Basic Circuits

Electronic Test Equipment

Transistors and Operational Amplifiers

Digital Electronics

LabVIEW Programming Concepts

LabVIEW Waveform Input/Output

LabVIEW Data Storage and Processing

Electrochemical Theory

Voltammetry

Electronic Circuit Design

Introductory Concepts. The electronics portion of the course began with a review of the basics of electricity. The material quickly moved to integrated circuits since these devices permit the construction of useful circuits without extensive consideration of design parameters. Electronic test equipment listed in Table 2 was provided at each laboratory station in a virtual form by means of a multifunction DAQ board and the graphical user interface (GUI) found in the software package (LabVIEW). In the strict since, virtual instruments are computer programs. However, in a broader view, virtual instruments result from the combination of these programs with the appropriate DAQ board. These "virtual instruments" supply the same functions as their traditional counterparts. However, providing instruments in this format is a more cost effective solution than purchasing the individual instruments and provides greater functionality since data may be shared between various computer applications.

Table 2. Virtual Instruments Provided by LabVIEW Software and DAQ board

Logging Voltmeter

Strip Chart Recorder

Oscilloscope

XY Recorder

Function Generator

Electrochemical Instrument

Data Acquisition Programming

Fundamental Concepts. Data acquisition programming transforms a computer such as a desktop PC into a device to record, manipulate, and display data; to produce stimulating signals; and in some cases to control and manage the overall experiment. LabVIEW was chosen as the data acquisition program for the course because it facilitates fast program development, provides many powerful built-in functions, and has universal acceptance in research and manufacturing settings. It is a graphical language where the program is written by placing and connecting icons which represent various built-in and user-developed functions on a block diagram. The connection of icons results in data flow execution of program nodes. For these reasons LabVIEW is the program of choice for the collection and distribution of data in analytical experiments.

LabVIEW GUI. LabVIEW provides a built-in graphical user interface (GUI) or front panel. The similarity of the front panel to real instruments allows the development of virtual instruments (VI's) which may be given their own icons and then used in future programs. Students appreciate the graphical nature of LabVIEW and often remark that programming is enjoyable taking on the qualities of a video game.

LabVIEW Programming. Students received instruction in LabVIEW programming by a combination of lectures on and practice with the software. The examples found in the Tutorial manual (1) were discussed in lecture. These topics included: the front panel; the block diagram;

building a VI; arrays and strings; loops; case and sequence structures; charts and graphs; file input and output; data acquisition; and debugging. Students also worked through the "Getting Started" and "Example VI's" sections of the Data Acquisition VI Reference Manual (2) to gain experience in analog input and output; counter and timers; and digital input and output. Different strategies in data acquisition were discussed to determine which would be most appropriate for a particular analytical experiment. To better understand the procedure by which the processor of a computer handles multiple tasks, the operation of the priority scheduler was explained in terms of a queue and interleaving (3). Analytical instruments require the computer to manage multiple tasks and to utilize different schemes depending on the type of analysis desired. A logical approach to design of LabVIEW applications is the canonical VI (4). The canonical VI represents methods of organizing tasks into modules which may be combined to form the application. Some canonical VI's considered included the initialize, loop, and shutdown; independent loops; the client-server; menu driven and the state machine. These VI's provide a framework from which a particular application may be generated.

Waveform Generation and Acquisition for Electrochemistry VI. After the students had gained experience with LabVIEW programming they were presented with the following assignment:

> Write a VI which outputs an array specifying the stimulating waveform and records two channels of data. The output and the input must start at the same time and continue until both are finished.

It soon became clear that by placing the start icons for both operations (array output and data recording) in one program sequence structure the two tasks would begin at the same time. However, the output data array must be loaded into the buffer and both tasks configured prior to the start icons. A wait icon would pause execution until all of the points in the output buffer were written. Since two channels of input were multiplexed the number of points acquired was twice the number generated. This scheme resulted in both tasks ending at the same time. An icon and a connector panel were created which allowed this VI to be used in another program (Computer-Controlled Electrochemistry Instrument VI).

Computer-Controlled Electrochemistry Instrument VI. The final programming assignment placed the Waveform Generation and Acquisition VI within a program which would perform various electrochemistry experiments. This assignment was stated as follows:

> Write a VI which will take a starting potential and a switching potential and generate a 1000 point array specifying a triangle wave for cyclic voltammetry experiments. Use a Ramp Pattern VI to generate an array describing a ramp for linear scan experiments. A third VI should be written which will take the starting potential, the switching potential, and the voltammetry scan rate (V/s) and determine the update rate for the Waveform Generation and Acquisition VI. Combine these VI's to produce an instrument which can accomplish cyclic voltammetry, linear scan, and stripping analysis experiments. Stripping analysis requires a timed electrolysis prior to a linear scan.

Two Ramp Pattern VI's were combined to produce a triangle wave. The starting potential was the initial value for one ramp and the final value for another. The switching potential was the final value for the first ramp and the initial value for the second ramp. Each VI produced an array of 500 samples. The two ramps were combined with a Build Array VI which yielded an array of 1000 samples. A second Build Array VI was used to convert the array into a two dimension array. However, this array only has elements in one column. A Transpose 2D Array VI was used to convert the array from a row major to a column major configuration as required by the AO Write VI. The update rate was determined by multiplying the absolute value of the difference of the start potential and the switching potential times the reciprocal of the voltammetry scan rate (V/s). This yielded the time period of the experiment in seconds. Dividing the number of updates by the period gave the update rate (updates/s) for a linear scan experiment. Dividing the linear scan update rate by two resulted in the update rate for a cyclic voltammetry experiment. The Electrolysis VI provided a timed electrolysis prior to any further voltammetry as required for stripping analysis. It consisted of an AO Write One Update VI and a Wait VI. An artificial data dependency was created to a case structure which was used to select the proper stimulating waveform array for cyclic voltammetry, linear scan, or stripping analysis. This array was feed to the Waveform Generation and Acquisition VI along with the update rate and the scan rate from the Voltammetry Scan Rate VI. The output was displayed by using an XY Graph front panel indicator or could be saved to a file.

Recent Developments

Since the completion of the Fall 1994 class, two new developments have occurred which will enhance the future effectiveness of the course (5). Prentice Hall is offering a student edition of LabVIEW with an accompanying user's guide (6) and a computer interfacing and LabVIEW programming textbook (7) has been developed. This will permit students to have their own copy of LabVIEW to work with. The guide and textbook will provide more formal routes to learning programming skills.

References

1. *LabVIEW Tutorial*; National Instruments: Austin TX, 1993.

2. *LabVIEW Data Acquisition VI Reference Manual*; National Instruments: Austin TX, 1993; p. 1-16 to 1-73 and 13-1 to 13-7.

3. *LabVIEW User Manual*; National Instruments: Austin TX, 1993; 19-5 to 19-8.

4. Johnson, G. *LabVIEW Graphical Programming*; McGraw-Hill: NY, 1993.

5. *Instrumentation Newsletter*; National Instruments: Austin, TX, Winter 1994/1995.

6. Wells, L.K. *LabVIEW Student Edition*; Prentice Hall: Englewood Cliffs, NJ, 1994.

7. Eaton, J.K., Eaton, L. *LabTutor, A Friendly Guide to Computer Interfacing and LabVIEW Programming*; Oxford University Press: New York, 1995.

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