Use of LABTECH/CONTROL in Microcomputer Based Instrumentation

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Abstract

LABTECH/Control or ASYST Data Acquisition Software is used in all of our laboratory experiments in the Department of Technology, at the University of Maryland Eastern Shore. Last few summers, a short course was offered to High School and Middle School Technology teachers. Purpose of the short course was to upgrade their knowledge in current technologies. Data Acquisition and Control was one of the topics covered. A laboratory was set up for their hands-on experiences. To purchase the equipment and the software, several manufacturers were contacted. After weighing the advantages and disadvantages of the several data acquisition boards and data acquisition and control software, a multi-purpose, 12 bit data acquisition board from Cyber Research Inc. and LabTech/Control data acquisition and control software from Laboratory Technologies were purchased. Short course covered principles of data acquisition and programming using LabTech/Control software. Our experience with the new system was excellent. Teachers were able to learn the basic functions of the software and were able to write application programs after very brief introduction and a guided use.

Our brief experience with LabTech/Control indicate that software programs with Graphical User Interfaces (GUI) like LabTech/Control can easily be taught in the Instrumentation and measurement courses offered in Engineering and Engineering Technology programs.

The new system was recently used in a short research to measure capacities of different types of batteries available on the market. Results indicate that alkaline batteries last about three and rechargeable alkaline batteries last about twice as much as of regular carbon batteries. Life of rechargeable Ni-Cd batteries were about 20% less than the rechargeable alkaline batteries.

The system was also used in acquiring the data from a Wheel Balancing Machine. However, since high acquisition rate and on-line manipulation of the acquired data was required, LabTech/Control's functions were found to be inadequate.

The main purpose of this paper is to give readers an overview of the LABTECH/CONTROL data acquisition software and talk about its applications at the University of Maryland Eastern Shore.

Introduction

Data acquisition systems are instruments that are used to acquire, display and process the incoming analog and digital signals. Most systems can also be used to control processes since they can send digital or analog signals to control devices. Data acquisition systems are similar to Data Logging systems but they can acquire data faster and they are more flexible in data processing and display. Our first microcomputer based data acquisition system (CDAS) was purchased in 1989 using an National Science Foundation grant. Initially, the system was used for Tensile Testing of Materials in Strength of Materials course. Since then, the use was extended to Creep Testing in the same course and to two experiments in Heating Ventilating and Air Conditioning (HVAC) course. In HVAC, the system is used in temperature and flow measurements. ASYST data acquisition, analysis and graphics software was used to write the application programs for CDAS to acquire, display, and process the data for all four of the experiments mentioned. Due to very long learning curve of the ASYST software, students are not required to write any data acquisition programs.

Recent developments in software design enabled data acquisition software manufacturers to use Graphical User Interfaces (GUI). GUI is an interface, for users like us, where symbols can be dragged and combined to create a flow chart for the data acquisition process. Therefore, GUI is an effective tool to reduce time consuming job of preparing application programs. With the introduction of GUI, preparation of an application program became an easy task. While the software became more user friendly, plug-in board manufacturers came up with products which are faster, more reliable, more accurate and require less installation, calibration and set-up times.

Selection of Hardware and Software

Selection of hardware, software and type of the system are major decisions. If you are getting ready to purchase a data acquisition system, several good papers are available on the subject [1-7]. Maximum throughput speed may be very important depending on the application. Most measurements in engineering are steady state measurements which do not require high speed acquisition. In new multi-purpose boards, throughput speeds range from 7.5 KHz to 1 MHZ or above. High speed boards are more expensive. 10 Hz throughput is more than sufficient for most steady state measurements. Unless software is selected properly, both software and hardware will limit the acquisition speed. For high speed applications, due to bandwidth limitations of ISA computer bus, it is advisable to purchase a PCI data acquisition board [6].

Computer-based or software programmable stand-alone systems require programming skills. Since our experience has been with the CDAS, I shall not be able to comment on stand-alone software programmable instruments. A PC based data acquisition board or system will require programming. In programming, one can use high level languages like Quick BASIC, BASIC, Visual BASIC, C++, Visual C++ etc. Most board manufacturers will supply example programs free of charge. These are written in one of the high level languages but are not sufficient to do a good job in displaying the data. Applications-programming languages, like ASYST [8], which is designed for data acquisition, graphics and analysis are also available. Although it is very flexible, learning a new programming language is a time consuming job. If long learning curves need to be avoided and most time be spent on measurements rather than programming, the only way to go is to use GUI (graphics or Icon) based software programs. Internally, all of these software packages either will write a high level computer program or prepare a set of instructions for an applications software to do the job. In icon based software, user drags few icons to prepare a flow chart for data acquisition, display, storage, control and analysis.

LABTECH/Control and LABTECH/Notebook from LabTech [9], LabVIEW from National Instruments [10], TestPoint and EASIEST from Keithley Metrabyte [11], DT VEE from Data Translation [4] are the most commonly used GUI based programs. Which one of these to select will depend on user requirements, the capabilities of the software, current price, discount for the education and availability of drivers for the selected or previously acquired data acquisition boards.

Analysis and Control capabilities, and being able to modify the set-parameters while system is acquiring the data (on-line changes) is a big plus. Analysis and Control capabilities will include operations on the signals being acquired (addition, subtraction, scaling, FFT, etc), conditional decision making (if-then, etc), and proportional-integral-differential (PID) control. All of the software programs listed above do support analysis and control functions. However, at the time of our software purchase, in June 1994, LabTech/CONTROL was the only one which allowed on-line set-parameters changes.

Short Overview of LABTECH/CONTROL Software

In 1994, we purchased DOS version of LABTECH/CONTROL software from Laboratory Technologies [9]. In 1995 we upgraded it to a newer Windows 3.1 version (Version 5.02). I installed the software on a TDK 486 computer with 8MB of memory running at 33MHz. Although, at that time I had a fairly fast computer, installation of the Windows version of the software was a time consuming job. Since I wanted to use the software with Cyber Research DAS-1601 and Data Translation DT-2805 boards, I installed the drivers for both boards. However, simple tasks like adding a different voltage range of the already installed board turned out to be another time consuming job. Upon my request, a DOS version of the software was provided free of charge. In DOS version, one can change drivers very easily and in a very short time. In Windows 3.1 and OS2 versions, high speed data acquisition is not possible. Under DOS, with high speed, acquisition rates may reach up to the board data acquisition speeds.

LABTECH/CONTROL menu organization is given in Table 1. When any menu item is activated, a parameters page with default parameters, is displayed.

Any parameter that needs to be changed may be entered into tables. An example parameters page for "Setup-Blocks-Normal" (normal speed data acquisition setup) menu item is given in Table 2. Except at High-Speed acquisition, "ICON-VIEW" menu item may be used to access the same pages by double-clicking on the icons.

When the cursor is positioned on the items which are in square parenthesis and "F1" key is hit, a selection-menu is displayed at the upper right hand side of the screen. The displayed selection-menu of the item "Block Type" is also shown in Table 2. One can scroll up or down to the item and hit "Enter" key for selection. When an item is entered into square parenthesis, its default parameters are also entered into the other parts of the page. Block type and the related default parameters are automatically entered when Icon-View is used.

In LABTECH/CONTROL three different types or groups of blocks are defined. A block is an operation for which a set of parameters are defined. An input block, for example, has a set of parameters that data acquisition board uses during data acquisition. The same blocks are used with menu-items and Icon-View. In Icon-View, blocks are visible on the screen. They may be dragged to the main area of the screen to create a program. Default parameters of the block may be displayed

Table 1. LABTECH/CONTROL Menu Organization

Main-Menu	Sub-Menu	Sub-Sub Menu	Function
SETUP			Set up Data Acquisition and Control
	BLOCKS		Initialize Data Acquisition and Control
		NORMAL	Normal Speed Acquisition
		HIGH-SPEED	High Speed Acquisition
	LOGS		Set up Logging on Disk
	DISPLAY		Set up Real Time Graphic Data
		SCREENS	Set up Graphics Display
		TRACES	Set up Graphics Trace Display
		ADJUST	Position Windows
		PAINTBRUSH	Run Paintbrush Program
	VERIFY		Display and check Set up Conditions
	SAVE/RECALL		Retrieve/Store Set up Conditions
		SAVE	Store Current Set up Conditions
		RECALL	Recall previously stored Set up Conditions
		DELETE	Delete previously stored Set up Conditions
	ICON-VIEW		Object/Iconic View
GO			Perform Data Acquisition
ANALYZE			Off-line Data Analysis
	EXTERNAL		Perform Data Analysis (123)
	CURVE-FIT		Fit Theory to Data
		SETUP	Set up Curve Fitting Model and Data
		EXECUTE	Execute Curve Fit
	FFT		Perform Fast Fourier Transform
		SETUP	Set up FFT
		EXECUTE	Execute FFT
INSTALL			Options or Hardware
	OPTIONS		Set ANALYZE Program name, etc.
	HARDWARE		Install Hardware Boards
	RS232		Set RS232 Options
QUIT			Exit to the Operating System

Table 2. Information Page for "Setup-Blocks-Normal" Menu item

Current Value: Analog Input

NORMAL DATA ACQUISITION / CONTROL SETUP

Number of function blocks [0..75]	6
Current block(s) [n or n..m]	
Block Type	[Analog Input]
Tag Name	
Block Units	
Interface Device	[1: DAS 1601]
InterfacePt./Channel No [0..15]	
Input Range	[+-10 V]
Scale Factor	1.00
Offset Constant	0.00
Hi-Hi Alarm Limit	10.00
Hi Alarm Limit	1.00
Low Alarm Limit	-1.00
Lo-Lo Alarm Limit	-10.00
Alarm Deadband	0.100
Alarm Processing	[Annunciate]
Buffer Size	1000
Number of Iterations [1..2000000000]	1
Number of Stages [1..8]	1
Stage Number	1
Sampling Rate, Hz	0.1
Stage Duration, sec. [0..1E8]	1.00e+06
Start/Stop Method	[Imbed.]
Trigger Block or Key	0
Trigger Pattern to AND [0..255]	0
Trigger Pattern to XOR [0..255]	0
Time Delay, sec. [0..1E8]	0.000
Analog Trigger Value	0.000
Analog Trigger Polarity	[High]
Number of Samples to Save (Pretrigger)	5

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by double clicking on the icon, and can be modified. In addition to input block type there are "output"
and "calculation" blocks. Blocks which are visible on the screen, when Icon-View is activated, are listed in Table 3.

If your data acquisition board supports, all of the Input and the Output icons listed in Table 3 may be used. Calculation type icons may be used with any board. Most of these icons may be converted to any other icon-type by changing the "Block Type" in the parameters page. If the board does not support the icon, you will not be allowed to enter the channel number of the board where the input or the output needs to be connected. For example, if your board does not have a counter input, software will not allow you to assign a channel number in the parameters page of the "Counter" input icon. Any other parameters which are not supported by the board can not be entered into page or will not appear in the selection list. After the program starts running, one can display the "On-Line

Table 3. Input, Calculation and Output Type Blocks Used in Icon-View

Input Type (Blue Colored)	Calculation Type (Yellow Colored)	Output Type (Green/Yellow Colored)
Analog	F(x,y)	Analog
Digital	C-Icon	Digital
Strain	Time	GPIB
Thermocouple	Reset	Pulse
RTD		Echo-Analog
Frequency		Echo-Digital
Resistance		PID
Counter		ON/OFF
Thermistor		Screen - Display
RS232		File - Data Storage
GPIB		
Replay		
Keyboard		

Control" screen by hitting the F1 key. Some parameters in most blocks may be changed while the system is acquiring, processing and storing the data. Menu items for the "On-line Control" screen are given in Table 4. With the Real-time Vision software, which is included with LabTech/Control, one can build operator interfaces to graphically display data and control the processes in real time.

Table 4. Menu Items for the On-line Control Screen

Menu Name	Function
CONTROL	Modify Control Loop Parameters
LOGS	Enable/Disable Data Logging
NOTES	Type Notes Into Data Logs
BLOCK	Change Alarm Limits and Scaling
ALARM	Enable/Disable Alarm Logging and View Alarm Summary
Keyboard	Enter Keyboard Data into "Keyboard" Blocks

Our Experiences With the Software

(a). Summer Short Course

During the 1994 and 1995 summers, a short course on Data Acquisition and Control was offered to High School and Middle School Technology teachers. Purpose of the short course was to upgrade their knowledge in current technologies. During the four day course Statics and Structures, Computer Control and Data Acquisition, Electronics, and Fluidics topics were covered. For each section, six hours of instruction and laboratory time was given. During about four hours of basic instruction, basic components of instrumentation systems, process control principles, digital to analog conversion, analog to digital conversion, data logging systems, data acquisition systems, and sources of hardware and software were covered. The remainder of the time (about two hours) were used for teaching LabTech/Control and writing basic data acquisition programs. In the laboratory, a DAS 1601, multi-purpose, 12 bit data acquisition board with screw terminal ($585+$80=$665) from Cyber Research Inc. and LabTech/Control ($895) data acquisition/control software from Laboratory Technologies were used.

Our experience with the new system was excellent. Teachers were able to learn the basic functions of the software and were able to write programs after very brief introduction. DOS version of LabTech/Control was used for faster response. Programming was taught on computers, in our computer room, with no data acquisition boards installed. Input signals were generated by the software. Real acquisition programs were also written by teachers on another computer with the data acquisition board. A signal generator wave-form was acquired, displayed and stored in a file. Laboratory has been a fun activity for teachers.

(b). Battery Life Comparisons

Fig.1 shows voltage versus time curves for different types of batteries. With the introduction of rechargeable alkaline battery and the claims that came with it, I was curious to see how good they are as compared to other battery types. In the study, AA-size regular-carbon, alkaline, rechargeable alkaline and rechargeable Ni-Cd batteries were compared. Using an 8-pack battery holder, with four batteries in it, and the Data Acquisition system, batteries were discharged through a constant resistance of 5 and 10 ohms. Voltage of each battery was monitored as a function of time to calculate the total energy stored. Voltage values were stored as a function of time in a file for later viewing, graphing and analysis. Voltages were continuously displayed in a digital and graphical form as the measurements continued. The Cyber Research DAS-1601 board with a screw terminal and LabTech/Control software was used. Programming for four channel analog input, four digital voltage display screens, four graphical voltage display screens, two digital time display screens and one file storage instruction required 8 icons. I was done with the programming in less than an hour. The Icon-View program for the acquisition, display and storage of the data, for this research, is given in Fig.2.

Results indicate that regular alkaline batteries last about three times and rechargeable alkaline batteries last about twice as much as of regular carbon batteries. Life of rechargeable Ni-Cd batteries were about 20% (assuming 1 volt is the end of life) less than rechargeable alkaline batteries. A substantial degradation of power is seen between the first and the second charge for rechargeable alkaline batteries. Subsequent charges of up to 5, showed negligible decrease in life of the batteries for both Ni-Cd and Rechargeable Alkaline batteries. Although starting voltages for rechargeable alkaline batteries were higher, Ni-Cd batteries maintained their voltage longer.

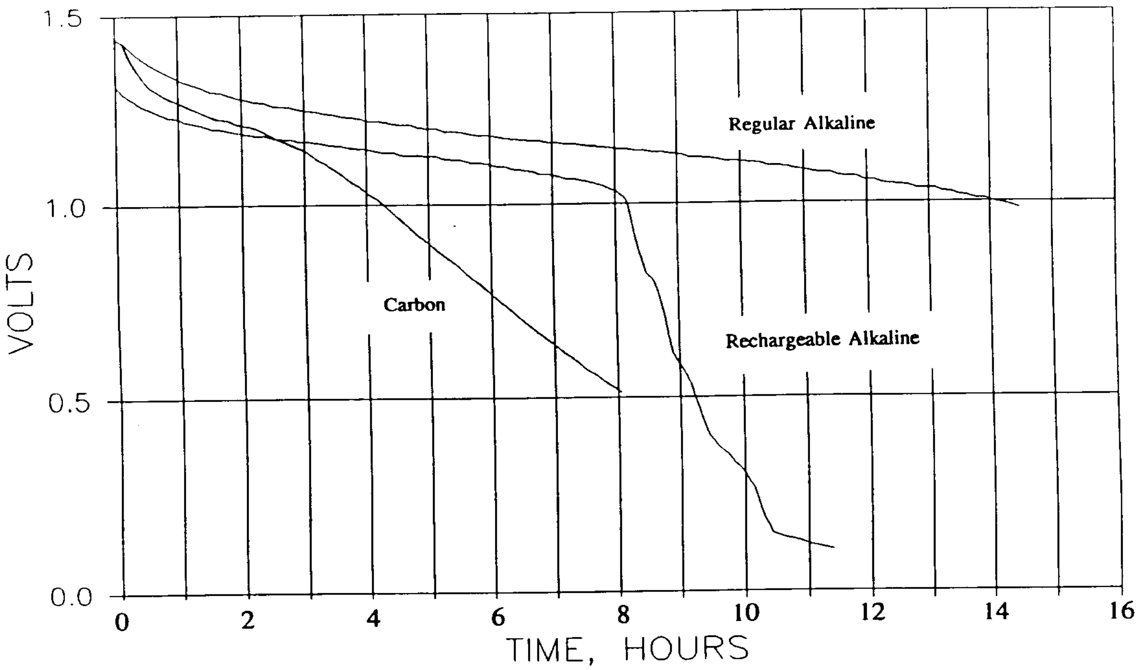

Figure 1. Battery Discharge at 10 Ohm Load (Average of 4 batteries).

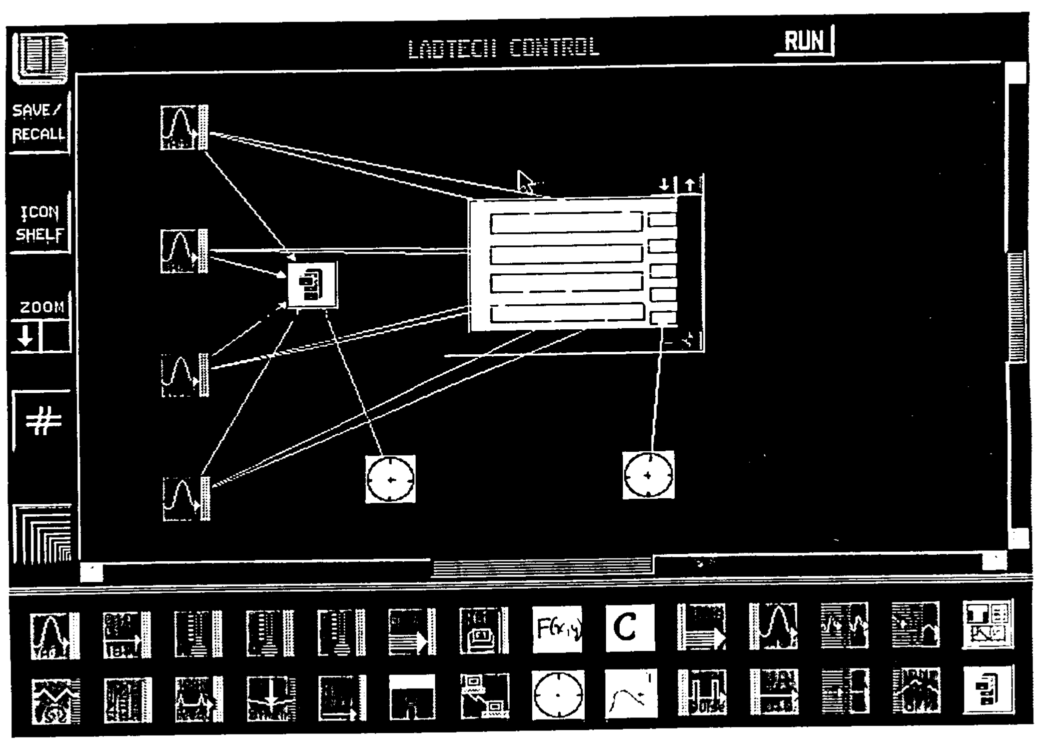

Figure 2. Iconic View of LabTech/Control for Battery Discharge Program

(c). Wheel Balancing Machine

A wheel balancing machine was designed and constructed by Mechanical Engineering Technology Students. Mechanical design and the construction was finished in one year. We are still struggling with the instrumentation of the wheel balancer. The machine consist of a shaft driven by an electric motor at 600 rpm. Wheel is attached to the end of the shaft. An accelerometer, attached to the machine frame is used to measure the unbalance force in the wheel. An encoder attached to the shaft is used to measure the location of the unbalance force in the wheel.

To be able to measure the angular position within one degree resolution, a data acquisition rate of 3600 Hz (=360 deg/rev * 600 rev/min / 60 sec/min) is required. However, by experience it was found that, at Normal Speed acquisition, max acquisition rate with 4 blocks (Analog input, Digital Input, Trigger and File Storage) was about 1500 Hz. Since data acquisition board can sample up to 100 KHz, 1500 Hz is a software and computer speed limitation. Use of Pentium 120 MHZ computer has increased the acquisition speed up to about 2000 Hz. Since on-line display and the processing of the acquired data is required to find the location and the value of the counter weight to be placed, more than 4 blocks are needed for the program. Any increase in the number of blocks will reduce the acquisition speed well below 1500 Hz.

Software's high speed acquisition rate is only limited by the number of blocks used in the program. When DAS 1601 data acquisition board is used with a 4-block program, up to 25 KHz (=100kHz/4) acquisition rate is possible. Since at high speed, on-line processing and the display of the data is not possible, high speed acquisition can not be used for wheel balancing machine. However, the software was helpful in debugging the instrumentation problems and in writing an ASYST program.

(d). Future Plans

During the last few years we planned to incorporate use of Data Acquisition Systems and Programmable Logic Controllers into laboratory exercises in the Engineering Technology Instrumentation courses. Unfortunately, to date, inclusion did not materialize due to time constraints and other priorities of the faculty teaching the course. We still hope to establish at least one data acquisition experiment for the Instrumentation course where student wills learn how to write programs and use the data acquisition system. Meanwhile, the system shall continue to be used in student design projects and in the independent study courses.

Conclusions

Our brief experience with LabTech/Control indicate that software programs with Graphical User Interfaces (GUI) like LabTech/Control can easily be taught in the Instrumentation courses offered in Engineering and Engineering Technology programs. Hopefully, starting with the Fall semester of 1996, Data Acquisition with LabTech/Control shall be incorporated into Instrumentation and Measurement courses in Mechanical and Electrical/Electronics Engineering Technology programs. Meanwhile, the use of Data Acquisition System with LabTech/Control shall continue in student design projects and in the independent study courses.

The importance of laboratory experiences for students can not be overstated. Laboratory work provides them with direct experiences of testing various physical principles. It also provides experiences in handling equipment and training in experimental sciences which is necessary for them to ultimately carry out experiments and measurements themselves. Such experiences are provided by scheduled experiments in several courses. In four of these scheduled experiments, data acquisition system is being used to give students additional hands on experience and information on modern ways of acquiring, analyzing and displaying the data. In two of the experiments in Strength of Materials course and in two of the experiments in Heating, Ventilating and Air Conditioning course Computerized Data Acquisition System is being used. However, in these experiments students do not write data acquisition programs. In general, students like all experiments, and use of the data acquisition system is always welcomed.

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