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PAKIETY PROGRAMOWE DLA CELÓW AUTOMATYZACJI POMIARÓW I PRZETWARZANIA DANYCH

Streszczenie. W artykule opisano pakiety programowe LabWindows i LabVIEW wspierające proces uzyskiwania programów użytkowych służących do zbierania, przetwarzania i prezentacji danych pomiarowych za pomocą komputera klasy IBM PC. Pakiety te obejmują bogaty zestaw programów bibliotecznych dla w.w. celów. Pakiet LabView wykorzystuje środowisko programowe MS Windows, natomiast pakiet LabWindows wspomaga programowanie w języku C.

SOFTWARE SYSTEM FOR AUTOMATIC MEASUREMENT AND DIGITAL SIGNAL PROCESSING

Summary. LabWindows and LabVIEW are software packages that save developing time of data acquisition and signal processing applications from American company National Instruments. They include powerful libraries for data acquisition, data analysis and data presentation tasks. System LabVIEW brings new powerful methodology of graphical programming and because of running under Microsoft WINDOWS it has all advantages of graphical environment typical for MS WINDOWS programs. LabWindows on the other hand is development system for traditional programmers who works with C programming language.

DIE PROGRAMMKOMPLEXE FÜR DIE AUTOMATISIERUNG DER MESSUNGEN UND DATENVERARBEITUNG

Zusammenfassung. LabWindows und LabVIEW sind in der amerikanischen Firma National Instruments gebildete Programmkomplexe, welche die zur Entwicklung der Anwendungen für die Datenerfassung und die Signalverarbeitung notwendige Zeit wesentlich sparen. Sie schliessen leistungsf ahige Programmbibliotheken ein, die Durchf thrung der atenerfassung, Datenanalyse und der graphischen Darstellung der Ergebnisse erm oglichen. Das System LabVIEW bietet eine neue leistungsf ahige Methodik der graphischen Programmierung. Da dieses System in der Umgebung MS WINDOWS funktioniert, hat es alle für die MS WINDOWS Programme typischen Vorteile der graphischen Umgebung. Lab Windows ist im Gegenteil ein Entwicklungssystem für traditionelle Programmierer, die die Rechnersprache C verwenden.

1. INTRODUCTION

Without measuring and evaluation the processed data it is impossible to imagine any technical and development activity. The first generation of instruments were analog instruments manually controlled from their front panels. The users had no flexibility in user interface design, measurements capabilities, or computational features.

With invention of General Purpose Interface Bus (GPIB), users could control the measuring systems both programatically and manually. Each GPIB instrument was designed for a specific measurement so a number of instruments was needed to create and complete measurement system.

Today's instruments are combination of general-purpose computer and workstations, graphical software, programmable instruments and general purpose digitizers. Modern instruments also combine sophisticated signal routing and conditioning, as well as programmable triggering schemes.

Software plays very important role in developing automated data acquisition and control systems. Application software packages gives to the user the tolls to acquire data, analyse data and present them by the computer. By using powerful software development packages it is possible to reduce the development time and create high quality programs that are easy to modify and maintain.

Many vendors offer application software for all three elements of automated data acquisition, control and DSP system (Data Acquisition, Data Analysis and Data Presentation). In many cases the offered software focuses only on the one of the mentioned element, and may be well suited for particular application. However, most applications requires software for all three elements of the system.

American company National Instruments, leader in hardware and software instruments for data acquisition and instrumentation offers two primary software packages LabWindows and LabVIEW that are going to became the world standards. These software packages build upon National Instruments industry standard device driver software. The packages include powerful data analysis routines for digital signal processing and statistical calculations. Each package also has very good data presentation capabilities for graphical user interface on the computer screen as well as plotting them on plotters or graphical printers and storing or retrieving the measured and processed data from files.

Both LabWindows and LabVIEW are complete programming systems, both products have the functionality and flexibility to meet any application. The differences are in programming methodology and the operating systems under which the packages run. LabWindows for DOS enhances the standard C and BASIC programming languages for data acquisition and control applications, LabVIEW is a graphical programming system for both nonprogrammers as well novice or advanced programmers. LabVIEW runs under Microsoft WINDOWS on PC compatible computers and integrates all capabilities of graphical systems. The usage of LabVIEW is not restricted only of IBM PC compatible computers, but also versions of workstations (SUN, Apollo, etc..) and VAX systems are available.

Let's describe the features of both systems to demonstrate their advantages.

2. LABWINDOWS - DEVELOPMENT SYSTEM FOR TRADITIONAL PROGRAMMERS

LabWindows is an integrated set of software tools of developing programs in Microsoft C and QuickBasic. This software package includes libraries for data acquisition, data analysis and graphical presentation. LabWindows helps the user to write and debug the programs in very effective way. Because all of the LabWindows libraries are compatible with QuickBasic and C the programs developed in this interactive program can be simple compiled and linked using the standard QuickBasic, C or Quick C compilers. The interactive development programs has a special interface called a function panel that allows the user to experiment with library functions and automatically generates source code for the user application. With LabWindows libraries it is very simple to create many of "virtual instruments" that can represent functions of real physical instrument by the help of LabWindows software, PC/XT/AT and data acquisition board or suitable interface board.

LabWindows has three libraries for data collection : GPIB library, RS 232 library and Data Acquisition library. The last one gives the user a wide set of functions for controlling data acquisition boards (preferred National instruments' data acquisition boards). Because LabWindows has functions for creating multiplot graphs, bar charts and strip charts and also special library - Advanced analysis library with many of functions for signal processing it is

ideal software tool for developing programs for monitoring technological processes and controlling.

The paper deals with application LabWindows software tools for developing control program for automatic monitoring and controlling workplace for measuring parameters and characteristics of electrical machines. For the measurings and control is used a low-cost data acquisition board from National Instruments - board Lab PC.

LabWindows requires an IBM PC AT, PS/2, or compatible computer running MS DOS version 3.0 or later. To run LabWindows interactive environment it is necessary to have 640 kilobytes of conventional memory and 1.4 megabytes of extended memory (it is recommended to have at least 3.4 megabytes of extended memory). To use LabWindows compiled programs it necessary to have only 640 kilobytes of conventional memory.

For creating executable programs LabWindows requires either Microsoft QuickBasic 4.x, Microsoft BASIC 7.0, Microsoft C 5.x or 6.x or Quick C 2.x. It is also possible to compile programs with Microsoft C 7.0 with the restriction of creating only batch file as product of utility LWMAKE, because Microsoft C 7.0 runs in Enhanced mode of 80386 microprocessor and needs for the work memory extender not compatible with DOS 16/M DOS extender from Rational System Inc. incorporated inside LabWindows environment or must be run under Microsoft Windows 3.0 or 3.1 with the virtual memory manager (VMM) incorporated inside Microsoft Windows. LabWindows on the other hand cannot run under Microsoft Windows as a Windows application. It can be run only as non Windows application, but only in a case if Microsoft Windows are running in real or standard mode. LabWindows cannot run at all at Windows in 80386 Enhanced mode.

For starting LabWindows in Standard mode the PIF file must be specified as follows:

- Required amount 1,024
- Limit -1

The LabWindows libraries unleash the full power of the C an QuickBASIC programming languages. The LabWindows libraries contain numerous functions for developing acquisition and control programs. LabWindows libraries are accessible both within the development system and in stand-alone programs. Libraries for C programming language are fully compatible with Microsoft Libraries so it is possible to link them to all programs written and compiled in Microsoft C versions mentioned above. The libraries use the large model of memory.

All library functions are callable by the help of function panels that are obtained after menu selection from Library menu command. The following libraries are available in LabWindows software development tool:

The GPIB Library contains the function for complete programming control of IEEE 488 (e.g. GPIB) instruments. With GPIB 488.2 Library it is possible to access any of National Instruments controller boards and the standard MS DOS device driver.

The RS 2323 Library has functions for performing serial communications using multiple RS 232 ports under interrupt control.

The optional VXI Library has functions to control VXI instruments from either VXIpc - 386 embedded VXI controller or external computers equipped with AT-MXI or MC-MXI interface. The library has functions for programming both Message Based and Register based devices.

The data Acquisition Library has functions to acquire and output data with all of National Instruments boards for IBM PC/AT, EISA and Micro Channel (PS/2) computers. The library contains both simple and sophisticated functions to give the user the maximum power and flexibility with the data acquisition boards.

The Instrument Library Developer Program (ILDP) satisfies all high demands for instrument drivers. Through the IDLP partnership with instrument vendors (also the Department of Electrical Measurements is one workplace where the instrument drivers are being written), the LabWindows Instrument Library continues to grow while maintaining a high standard of quality.

LabWindows provide to user Integrated Development Environment. All function are accessible from pull down main menu by selection from keyboard or by mouse pointer. The main menu contains the following commands: File, Edit, Program, Libraries, View and Option. File menu provides standard functions calling the utility LWMAKE for creating stand-alone executable programs by the external compilers (C or QuickBASIC) or for creating Run Time applications. This is useful on case of large program application, when the compiled code is useful in case of large conventional memory and cannot be directly executed under MSDOS operating system. The Edit menu provides functions for delete, move or copying text, and pasting text to and from files. The Program menu provides tools to assist in debbuging an application program. The syntax can be checked without executing the code. The breakpoints can be placed in the source code to halt the program at desired locations to be able then execute the program step by step and locate mistakes in the program. The Instruments provides

access to Instrument Library, which contains device control functions for various instruments. LabWindows development tool. The Libraries provides libraries that assist in writing application programs. These libraries include: Formatting I/O, User Interface, Graphics, Analysis, Data Acquisition, RS 232, GPIB, GPIB-488.2, VXI and System libraries. The Advanced Analysis Library - the optional library with wide range of functions for statistics and Digital Signal Processing replaces the regular Analysis Library.

These libraries provide functions mentioned above in previous paragraph. The View contains commands to invoke Variable Display, display the most recently used function panel or graph and enable the Split Screen mode. It also contains commands to switch between the various windows. The Option menu contains commands for calling the User Interface Editor or the instrument driver panel/tree editors. There are also commands for saving instrument driver code.

Programming with LabWindows is very simple. The Libraries menu item provides to user after selecting the library and specifying the function panel. A function panel is a full screen user interface for entering the parameters to functions and interactively executing library functions without typing and editing the program code. Generated source code can be put to the program window of editor by selecting the Keep command from Function Panel Menu. Interactive executing the library functions with filled parameters can be used for effective checking the validity of the parameters and correct function results.

3. ANALYSING SIGNALS IN LABWINDOWS - ADVANCED ANALYSIS LIBRARY

Advanced Analysis Library is powerful set of functions for data analysis and Digital Signal Processing. The Library contains signal generation algorithms and curve fitting functions. There are also numerous of utility functions for working with data arrays, complex numbers and complex arrays. In area of Digital Signal Processing Advanced Analysis Library provide functions in frequency Domain: computing FFT, FHT, Power Spectrum of signal, computing Convolution and Correlation. In time Domain there are available Integration, Differentiate, ArrayReversal and Pulse Parameters Computing. The library is very rich also in sphere of digital filtering. Advance Analysis Library provides functions for design both Finite

Impulse Response and Infinite Impulse Response digital filters, windowing functions (Hamming, Hanning, Blackman, Triangle and Kaiser). Also statistical functions are included to Advanced Analysis library. It contains variance, RMS, moments and median computing, linear and exponential curve fitting.

4. CONTROLLING THE ANALOG TO DIGITAL AND DIGITAL TO ANALOG BOARDS OF IBM PC XT/AT BY THE HELP OF LABWINDOWS - DATA ACQUISITION LIBRARY

Data Acquisition Library provides to the user powerful set of functions for controlling the acquisition boards available from National Instruments.

The acquisition functions can be divided into following groups: the single channel and scanned Data Acquisition functions and the multiply channel Data Acquisitions functions.

The single channel and scanned data acquisition functions are further divided into high-level data acquisition functions, low level data acquisition functions and double buffer ones.

Single channel data acquisition involves selecting a single analog input channel and gain of input signal setting. A/D conversion are performed on that channel once every sample interval.

Multiple channel scanned data acquisition scans sequence of analog input channels scanned. A sample interval indicate the tines to elapse between A/D conversions on each channel in the sequence. A single starting channel is all that is needed to select the sequence of channel to scan. The channel are then scanned on consecutive order.Both the single and multiply channel modes can be used with any of the following additional modes:

- Posttrigger mode
- Pretrigger mode
- Double-buffered mode

Posttrigger mode collects a specified number of samples after trigger is received. Post trigger mode acquisition can be initiated through software or by pulse edge applied to EXTTRIG input of National Instruments acquisition boards. Once the user's buffer has been filled, the data acquisition stops.

Pretrigger mod collects data before and after a trigger is received. Data acquisition is initiated through software. The acquisition board collects the data to use defined buffer until a pulse is received at the EXTTRIG input. Then the board collects specified number of samples and then stops the acquisition process. The user buffer is treated as circular buffer e.g. when the entire buffer has been written to, data or stored at the beginning again, overwriting the old data. So when the data acquisition stops the buffer contains data before and after the stop trigger occurred.

Double-buffer mode, like pretrigering mode also fills the user's buffer continuously. Unlike pretrigering mode however, double buffered mode transfers old data into second buffer before overwriting the old data with new data. Data is transferred out of one half of the user's buffer while the other half is being filled with new data. Double buffered mode can be used in conjunctions with either pretriger and posttriger modes.

The data Acquisition Library functions for controlling the acquisition process can be divided into two basic types asynchronous and synchronous data acquisition functions. The first class of functions works in following way: they initiates the acquisition process, which is still on going and then returns the control to program. The second class of functions don't return control to application program until process is finished.

5. CREATING USER INTERFACE WITH USER INTERFACE EDITOR

When developing the application program, there is always the problem how to design and develop the user interface for communication with the user e.g. to develop system for entering the input parameters from the keyboard and on the other hand to present measured physical values of scanned or processed signal. LabWindows solves this problem with powerful User Interface Editor with User Interface Library functions for controlling the behaviour of screen during the communication with user. LabWindows User Interface Library enables to the user to combine graphical panel (created completely in interactive way by User Interface Editor) and pull down menus for simple interactive operations of the program. The program can view measurement's data control operation of the system from custom designed application interface.

6. DATA ACQUISITION BOARDS FOR IBM PC XT/AT AVAILABLE FOR LABWINDOWS APPLICATION

LabWindows can control data acquisition boards designed for MC series board for the IBM PS/2 family of computers that uses Micro Channel Bus, PC AT and compatible computers and boards for EISA bus computers.

7. LABVIEW GRAPHICAL PROGRAMMING SYSTEMS - NEW APPROACH TO CREATING REAL TIME APPLICATIONS

LabVIEW is a graphical programming system for data acquisition and control, data analysis and data presentation. LabVIEW offers an innovative programming methodology in which the user graphically assembles software modules called virtual instruments (VI). LabVIEW is an alternative to the text programming. Similarly as in LabWindows also LabVIEW offers to the user tools of developing complete data acquisition application. To create a VI in LabVIEW means at first build the front panel with knobs, slides, switches, graphs, strip charts, and so on. The front panel serves as an interactive interface for supplying inputs to and observing outputs from an instrumentation system. This part of developing the application is similar to creating graphical interface by the help of User Interface Editor in LabWindows system.

To program the VI, the user must construct the block diagram free from the many syntactical details of conventional programming. This is the main difference from working under LabWindows development system. The user selects the functional block from palette menus and connects them with wires to pass data from one block to the next one. These blocks range fromsimple arithmetic functions to advanced acquisition and analyses routines, and to network and file I/O operations that store or retrieve data in ASCII, binary or even spreadsheet formats.

The block diagram methodology is based on modern programming concepts of object oriented and data flow programming. Data flow programming dictates that any object may not execute until all of its inputs are available and the object's outputs are not available until the object's function is completed. Thus the data flow of data between connected objects controls

the execution order. The execution order is not constrained to the sequential order of lines from a text based program. Free from the constraints of text based programs, it is possible to quickly develop application simply by connecting functional blocks together.

LabVIEW is a hierarchical system. Any virtual instrument (VI) can serve as subroutine for another VI. It is possible to use VI as subVI by adding its icon also created by LabVIEW system, in the block diagram of the final application. As in traditional, text based programming languages, LabVIEW contains structures that control the block diagram execution. Program control structures for LabVIEW include Sequence, Case statement, For Loop and While Loop. These structures are graphically depicted as border structures. The user just as normally imbeds code into the lines of a structure in conventional programming languages, now in LabVIEW places the icons within the borders of LabVIEW graphical structures. LabVIEW features a graphical compiler that generates optimised code. VI execute at speed comparable to those of compiled programs. In addition it is possible to execute LabVIEW Run Time System, a low cost compact form of LabVIEW development system.

CONCLUSIONS

Both systems are very powerful tools for developing application programs in sphere of monitoring and controlling technological process. But it has also a very good application in technical research laboratories, technical diagnostic, because of wide set of functions for data analysis, digital signal processing and data presentation. Also usage in educational process is very useful, because students could turn their attention to solve the technical problems concerning measuring, controlling and analysing the acquired data and they do not waste their time with programming the standard situations as are controlling the A/D acquisition boards and solving the graphical problems of presentation graphs and measured values.

LITERATURE

[1] LabWindows User Manual.

[2] LabVIEW User Manual.

[3] IEEE 488 and VXIbus Control Data Acquisition and Analysis National Instruments products catalogue 1993.

[4] D. Kaminský, Nová technologie - LabVIEW, CHIP 6, 1993, CS edition.

[5] D. Kaminský , Moderní softwarové systémy pro měření a diagnostiku, conference proceedings, Ostrava 1992.

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Streszczenie

Jeden ze sposobów budowania współczesnych systemów pomiarowych oparty jest na konstrukcji tzw. wirtualnego przyrządu pomiarowego. Idea budowy tego rodzaju przyrządu polega na szerokim wykorzystaniu sprzętowych i programowych możliwości, jakie stwarzają komputery klaszy PC. Wykorzystując standardowe oprzyrządowanie komputera poszerzone o odpowiedniej klasy karty wielowejściowych przetworników analogowo-cyfrowych buduje się wyspecjalizowane oprogramowanie, kreujące na ekranie komputera panel, służący do komunikacji operatora z tak zbudowanym przyrządem. W artykule przedstawiono dwa pakiety programowe, służące do konstruowania przyrządów wirtualnych: LabWkindows - realizujący powyższe zadania w tradycyjny sposób przy użyciu języka C oraz LabVIEW, wykorzystujący technikę ikon charakterystyczną dla systemu operacyjnego WINDOWS firmy Microsoft. Opisano środowisko sprzętowe i programowe obu pakietów oraz specyfikę ich aplikacji.