Appendix G

Commercial DSP Systems

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A wide variety of commercial data acquisition hardware and software is currently available in the market. Most comes in the form of full-fledged data acquisition systems that support various hardware cards in addition to data analysis and display capabilities. Basically a complete data acquisition system consists of three modules: acquisition, analysis, and presentation.

G.1 DATA ACQUISITION SYSTEMS

G.1.1 Acquisition

Four common ways of acquiring data use (1) an RS-232 serial interface, (2) the IEEE 488 (GPIB) parallel instrumentation interface, (3) the VXI bus, or (4) a PC-bus plug-in data acquisition card.

RS-232 interface

This approach consists of a serial communication protocol for simple instruments such as digital thermometers, panel meters, and data loggers. They are useful for controlling remote data acquisition systems from long distances at data rates lower than 1 kbyte/s. Since the RS-232 interface comes standard on most computers, no extra hardware is necessary.

IEEE 488 (GPIB) interface

Many sophisticated laboratory and industrial instruments, such as data loggers and digital oscilloscopes, are equipped with GPIB interfaces. Devices communicate through cables up to a maximum length of 20 meters using an 8-bit parallel protocol with a maximum data transfer rate of two Mbyte/s. This interface supports both control and data acquisition. IEEE 488 uses an ASCII command set (Baran, 1991).

VXI bus

This bus is a high-performance *instrument-on-a-card* architecture for sophisticated instruments. Introduced in 1987, this architecture has been driven by the need for physical size reduction of rack-and-stack instrumentation systems, tighter timing and synchronization between multiple instruments, and faster transfer rates. This standard is capable of high transfer speeds exceeding 10 Mbyte/s.

Plug-in data acquisition boards

Data acquisition boards plug directly into a specific computer type, such as the PC or the Macintosh. This method combines low cost with moderate performance. These boards usually support a wide variety of functions including A/D conversion, D/A conversion, digital I/O, and timer operations. They come in 8–16 bit resolution with sampling rates of up to about 1 MHz. They offer flexibility and are ideal for general-purpose data acquisition.

G.1.2 Analysis and presentation

Data analysis transforms raw data into useful information. This book is principally about data analysis. Most software packages provide such routines as digital signal processing, statistical analysis, and curve fitting operations.

Data presentation provides data to the user in an intuitive and meaningful format. In addition to presenting data using graphics, presentation also includes recording data on strip charts and generation of meaningful reports on a wide range of printers and plotters.

G.2 DSP SOFTWARE

The trend is toward using commercial DSP software that provides the entire process of data acquisition, analysis, and presentation. Here we discuss commercially available software for general plug-in PC data acquisition boards. Because of the flexibility of such a scheme of data acquisition, there is a huge market and many suppliers for such software. In addition, many vendors offer complete training programs for their software.

Software capabilities vary with vendors' emphasis and pricing. Some companies, for example, sell their software in modules, and the user can opt to buy whatever is needed.

Some common capabilities of commercial DSP software include the following:

1. Support of a wide variety of signal conversion boards.
2. Comprehensive library of DSP algorithms including FFT, convolution, low-pass, high-pass, and bandpass filters.
3. Data archiving abilities. The more sophisticated software allows exporting data to Lotus 123, dBase, and other common analysis programs.

4. Wide range of sampling rates.
5. Impressive graphics displays and menu and/or icon driven user interface.
6. User-programmable routines.
7. Support of high-level programming in C, BASIC, or ASCII commands.
8. Customizable report generation and graphing (e.g., color control, automatic or manual scaling).

A few interesting software packages are highlighted here to give the reader a flavor of what commercial DSP software offers.

SPD by Tektronix is a software package designed for Tektronix digitizers and digital oscilloscopes and the PEP series of system controllers or PC controllers. It offers in its toolset over 200 functions including integration and differentiation, pulse measurements, statistics, windowing, convolution and correlation, forward and inverse FFTs for arbitrary length arrays, sine wave components of an arbitrary waveform, interpolation and decimation, standard waveform generation (sine, square, sinc, random), and FIR filter generation.

DADiSP by DSP Development Corporation offers a version that operates in the protected mode of Intel 80286 or 80386 microprocessors, giving access to a full 16 Mbytes of addressability. Of interest is the metaphor that DADiSP uses. It is viewed as an interactive graphics spreadsheet. The spreadsheet is for waveforms, signals, or graphs instead of single numbers. Each cell is represented by a window containing entire waveforms. For example, if window 1 (W1) contains a signal, and W2 contains the formula DIFF(W1) (differentiate with respect to time), the differentiated signal will then be displayed in W2. If the signal in W1 changes, DADiSP automatically recalculates the derivative and displays it in W2. It also takes care of assigning and managing units of measurement. In the given example, if W1 is a voltage measurement, W1 will be rendered in volts, and W2 in volts per second. As many as 100 windows are allowed with zoom, scroll, and cursoring abilities. The number of data points in any series is limited only by disk space, as DADiSP automatically pages data between disk and memory.

DspHq by Bitware Research Systems is a simple, down-to-earth package that includes interfaces to popular libraries such as MathPak87 and Numerical Recipes.

MathCAD by MATHSoft, Inc. is a general software tool for numerical analysis. Although not exactly a DSP package, its application packs in electrical engineering and advanced math offer the ability to design IIR filters, perform convolution and correlation of sequences, the DFT in two dimensions, and other digital filtering.

A more powerful software package, MatLAB by Math Works, Inc., is also a numerical package, with an add-on Signal Processing Toolbox package having a rich collection of functions immediately useful for signal processing. The Toolbox's features include the ability to analyze and implement filters using both direct and FFT-based frequency domain techniques. Its IIR filter design module allows the user to convert classic analog Butterworth, Chebyshev, and elliptic filters to their digital equivalents. It also gives the ability to design directly in the digital domain. In particular, a function called *yulewalk*() allows a filter to be designed to match any arbitrarily shaped, multiband, frequency response. Other Toolbox functions include FIR filter design, FFT processing, power spectrum analysis, correlation function estimates and 2D convolution, FFT, and crosscorrelation. A version of

this product limited to 32 × 32 matrix sizes can be obtained inexpensively for either the PC or Macintosh as part of a book-disk package (*Student Edition of MatLAB*, Prentice Hall, 1992, about $50.00).

ASYST by Asyst Software Technologies supports A/D and D/A conversion, digital I/O, and RS-232 and GPIB instrument interfacing with a single package. Commands are hardware independent. It is multitasking and allows real-time storage to disk, making it useful for acquiring large amounts of data at high speeds.

The OMEGA SWD-RTM is a real-time multitasking system that allows up to 16 independent timers and disk files. This is probably more useful in a control environment that requires stringent timing and real-time capabilities than for DSP applications.

LabWindows and LabVIEW are offered by National Instruments for the PC and Macintosh, respectively. LabWindows provides many features similar to those mentioned earlier. However, of particular interest is LabVIEW, a visual programming language, which uses the concept of a virtual instrument. A virtual instrument is a software function packaged graphically to have the look and feel of a physical instrument. The screen looks like the front panel of an instrument with knobs, slides, and switches. LabVIEW provides a library of controls and indicators for users to create and customize the look of the front panel. LabVIEW programs are composed of sets of graphical functional blocks with interconnecting wiring. Both the virtual instrument interface and block diagram programming attempt to shield engineers and scientists from the syntactical details of conventional computer software.

G.3 VENDORS

Real Time Devices, Inc.
State College, PA
(814) 234-8087

BitWare Research Systems
Inner Harbor Center, 8th Floor, 400 East Pratt Street,
Baltimore, MD 21202-3128
(800) 848-0436

Asyst Software Technologies
100 Corporate Woods, Rochester, NY l4623
(800) 348-0033

National Instruments
6504 Bridge Point Parkway, Austin, TX 78730-5039
(800) IEEE-488

Omega Technologies
One Omega Drive, Box 4047, Stamford, CT 06907
(800) 826-6342

DSP Development Corporation

One Kendall Square, Cambridge, MA 02139
(617) 577-1133

Tektronix
P.O. Box 500, Beaverton, OR 97077
(800) 835-9433

MathSoft, Inc.
201 Broadway Cambridge, MA 02139
(800) MathCAD

The MathWorks, Inc.
21 Eliot St, South Natick, MA 01760
(508) 653-1415

G.4 REFERENCES

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Coffee, P. C. 1990. Tools provide complex numerical analysis. *PC Week*, (Oct. 8).
National Instruments. 1991. IEEE-488 and VXI bus control. *Data Acquisition and Analysis.*
Omega Technologies 1991. *The Data Acquisition Systems Handbook.*
The MathWorks, Inc. 1988. *Signal Processing Toolbox User's Guide.*