TEK APPLICATION INFORMATION

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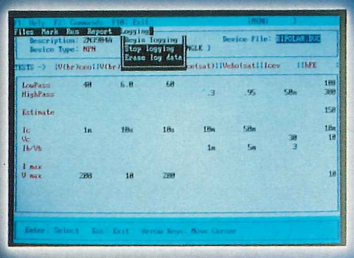
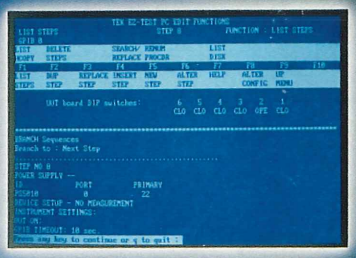
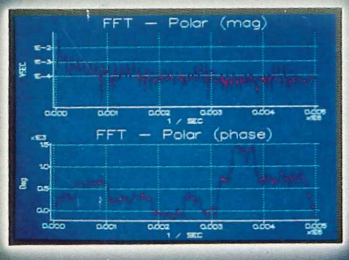
HANDSHAKE

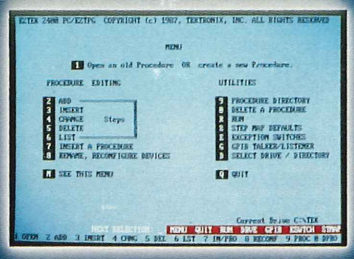
NEWSLETTER OF INSTRUMENTATION AND INSTRUMENT SYSTEMS

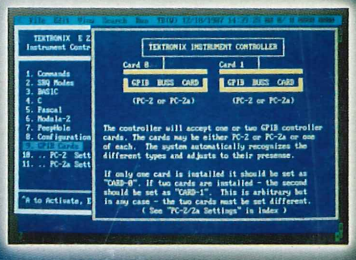
More Power For Your Measurements











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Introducing a new feature

With this issue, we begin a new **HANDSHAKE** feature to help solve your measurement problems — a question and answer column. If you have a question pertaining to signal measurements, drop us a line. We'll do our best to get an answer. Questions/answers of general interest to our readers will be printed in future Q&A columns.

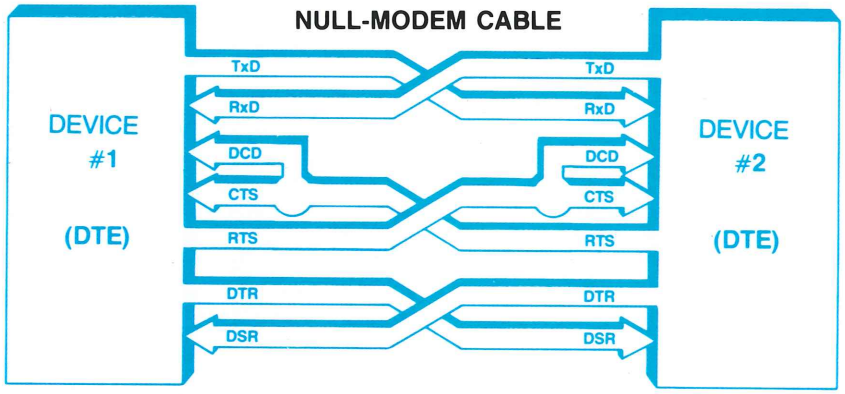
Null modem confusion

Q In reading the article on **Using the RS-232-C as an instrument interface** in the Fall 1987 **HANDSHAKE**, I became confused. The illustration in Figure 2 on page 23 seems to be different than the description given in the text. Is there more than one way to wire a null-modem?

A Yes, there are several possible ways to build a null-modem cable. The one shown in Figure 2 is a valid null-modem cable. This type of null-modem basically tells itself that it can send data when it is ready to receive data and tells the other device that a valid data channel exists. In essence, it "handshakes" itself.

Another type of null-modem cable is shown in the accompanying diagram. This null-modem better fits the handshaking description in the article. The RTS line from one device controls both the DCD and CTS line of the second device. This cable allows each device to "handshake" its partner to control the flow of data on its own receive channel (RxD).

Ray Kennedy
Portable Test Instruments Division



Foreign language help

Q Our 2430A is used by non-English speaking operators, yet all the "HELP" text is in English. Can I get a version with the "HELP" text in other languages?

A "HELP" text for the 2430A and the new 2432 is available in one of five languages as a no-charge option at the time of ordering — French, German, Italian, Spanish, or English (standard). Existing instruments can be retrofit to any one of these languages for a firmware upgrade charge. Contact your local Tektronix Service Center for upgrade information.

Marc Brenner
Portable Instruments Division

Questions?

Do you have a question on signal measurements? Send it to **HANDSHAKE** Q&A, M/S 02-382, P.O. Box 500, Beaverton, OR 97077. Your name and name of your company will be used with the printed question unless you specifically request that it be withheld.

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A look inside

With this issue of **HANDSHAKE**, we bring you more power for your measurements! The new PEP 301 Systems Controller introduced by the Personal Engineering Products Program (PEPP) is the first to bring the power of the 80386 microprocessor to instrument control applications. This powerful controller allows you to use the many Tekware software packages from Tektronix, as well as most of the hundreds of MS-DOS packages available today, for your measurements. You'll find complete details in **The PEP 301 Systems Controller — the first 80386-based controller tuned to your test and measurement needs** starting on page 4.

Instrument control using standard MS-DOS languages has always required compromise — until now! The article **EZ-BUS — converting standard languages** into GPIB controller languages describes a new software product designed specifically for use with the PEP 301 Systems Controller and your favorite MS-DOS programming language.

As a special feature, the chart on page 11 lists the MS-DOS Tekware packages currently available from Tektronix along with vital information about each package.

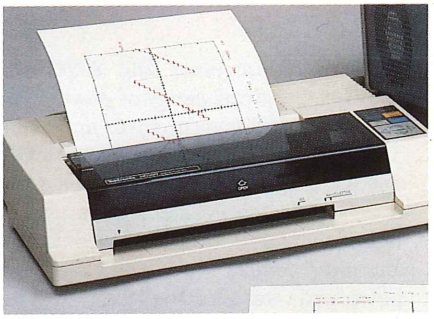
We also introduce some new measurement products in this issue. The **HC100 — Perfect companion for Tektronix digital storage oscilloscopes** describes a new color plotter that is optimized for use with Tektronix instruments.

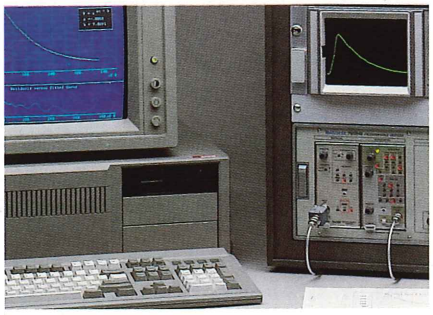
The new 300 MHz 2432 Digital Storage Oscilloscope expands the acquisition capabilities of the MP2601 Portable Measurement Package. The 2432 and MP2601 are both described in the article **MP2601 acquisition capabilities expanded.**

For our focus on applications, the article **Transient capture and analysis using the 7912HB and ASYST** describes how to acquire and display exponential decay data.

Unfortunately, we ran out of pages in this issue before we ran out of information. Look for the Spring '88 issue of **HANDSHAKE** for more new products and applications from Tektronix to help solve your measurement problems. If you'd like more information on any of the products described in this issue, or for help with your other signal measurement needs, contact your local Tektronix Field Office or sales representative. And be sure to tell them you saw it in **HANDSHAKE**.

A. Dale Aufrecht
HANDSHAKE Editor





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For information or prices on products described in this issue, call the Tektronix National Marketing Center 1-800-426-2200

The PEP 301 Systems Controller —

the first 80386-based controller tuned to your test and measurement needs

Dave Barnard
Personal Engineering Products Marketing
Portable Instruments Division
Tektronix, Inc.

A major shift is taking place in instrument control, from dedicated controllers to PC-based "open architecture" systems. Such open systems offer low-cost, general purpose instrument control and a growing base of applications software, as well as access to professional productivity tools that are in increasing demand in today's quality-conscious market.

Custom-configuring your own system, however, involves real risks. Most PCs and software packages are sold off-the-shelf by non-specialists. Suppose you've hand-assembled an IBM PC, a GPIB card from an independent vendor, and instrument control, data acquisition, and data analysis packages — all from different software vendors. If your data acquisition package can't capture the data, where's the problem, and who do you call to find out? Such problems dilute your measurement efforts and take valuable time that could otherwise be spent doing your real job — making measurements.

The PEP 301 — the first 80386-based systems controller

With the PEP 301 Systems Controller, Tektronix offers the world's first 80386-based instrument controller. The PEP 301 is an IBM PC/AT-compatible instrument controller built around the powerful Intel 80386 microprocessor and 80387 math coprocessor, giving plenty of power to handle almost any measurement application. The PEP 301 is optimized for both GPIB and RS-232-C instrument control. And its open architecture ensures that you can configure a system to match your unique test and measurement needs, while tapping the power and versatility of a PC-based system.

The PEP 301 comes standard with an installed GPIB interface card and the Tektronix GURU II GPIB support software with EZ-BUS, plus MS-DOS Version 3.2, GW-BASIC, and special display driver menu software. This means that when you purchase the PEP 301, you get a true system solution with everything you need to begin configuring your system and acquiring and analyzing data.

Furthermore, the PEP 301 has been thoroughly tested and tuned to run the complete line of Tektronix Tekware measurement software packages bug-free, without modification. Designed to help you get the most out of your PEP 301 controller, these application packages include software for use with the many Tektronix GPIB measurement instruments (see Figure 1). For a list of the currently available Tekware along with the instruments each package supports, see **MS-DOS Tekware At A Glance** in this issue. With the PEP 301/Tekware team, you're assured that all the pieces of your data acquisition and analysis system fit into a smoothly running, integrated solution.

Every effort has been made to ensure that the PEP 301 is truly PC compatible, including a multimode display, programmable clock rates, and extensive third-party software testing. We can't say that every PC software package ever built will run on the PEP 301 — just every one of the dozens and dozens that we've tested, including Lotus 1-2-3, Symphony, Framework, and dBase.

80386 means computing power and investment protection

The PEP 301 Systems Controller is built around an Intel 80386 — a state-of-the-art, 32-bit microprocessor, coupled with an 80387 numeric coprocessor — to give you unparalleled power to analyze and plot data. The PEP 301 delivers between 4 and 5 MIPS (million instructions per second). If that's a little abstract, just think of it as three to four times the computing power of a standard 8-MHz 80286-based system! In addition, the 16 MHz processor has full access to zero-wait-state memory, giving an effective processor speed about 20% higher than systems that use wait states in memory access.

The Tektronix PEP 301 Systems Controller provides high-performance instrument control for a wide range of test and measurement applications.

The 80387 numeric coprocessor also runs at 16 MHz and delivers about 1 MFLOPS (million floating point operations per second). That's about five times more FLOPS than in most PC/AT compatibles. And the 80386/80387 processors run both the 8086/8087 and 80286/80287 instruction sets, so existing applications for these earlier processors run unmodified.

What do all these fancy numbers mean? Three things. First, with the PEP 301 you can do things you just couldn't do before. For example, you now have the processor power to support a true windowed environment such as Microsoft Windows/386 at practical speeds, with "seamless" movement between concurrent applications.

Second, the PEP 301 places you at the forefront of microprocessor technology without compromising your current or future software investments. Existing 286-based applications will run unmodified on the PEP 301, while new applications you develop will have long, useful lives — they won't be obsolete next year or for years to come.

Third, with the PEP 301 you have room to grow. With the computing power of the 80386/80387 team, you won't overload the system just by adding another instrument or software package. You get the power to handle your growing measurement needs for a long time to come.

Figure 1. *The PEP 301 System Controller is supported by a full line of Tekware test and measurement software, all verified to run reliably on the PEP 301.*

Only part of the good news...

Powerful as the 80386 processor may be, without memory, display capability, and other system support, it would be about as useful as a car without wheels. The PEP 301 includes a full complement of integrated hardware and software components so you can use all those MIPS and FLOPS to get the maximum measurements per second from your instrumentation system.

The PEP 301 includes 1 Mbyte of fast, on-board RAM, a 32-bit address bus, a 32-bit data bus, seven DMA channels, 15 interrupts, and three programmable timers, plus standard RS-232-C serial, Centronics-style parallel, and IEEE-488 Standard GPIB interfaces. Also standard are a 40 Mbyte hard disk and a 1.2 Mbyte floppy disk that's read-compatible with 360K floppies. And when you fill these, there's room to add more drives — either "hard" or "soft." Figure 2 shows a block diagram of the PEP 301 system configuration.

A compatible BIOS. The BIOS (Basic Input/Output System) is key to the compatibility of the PEP 301 with all of the

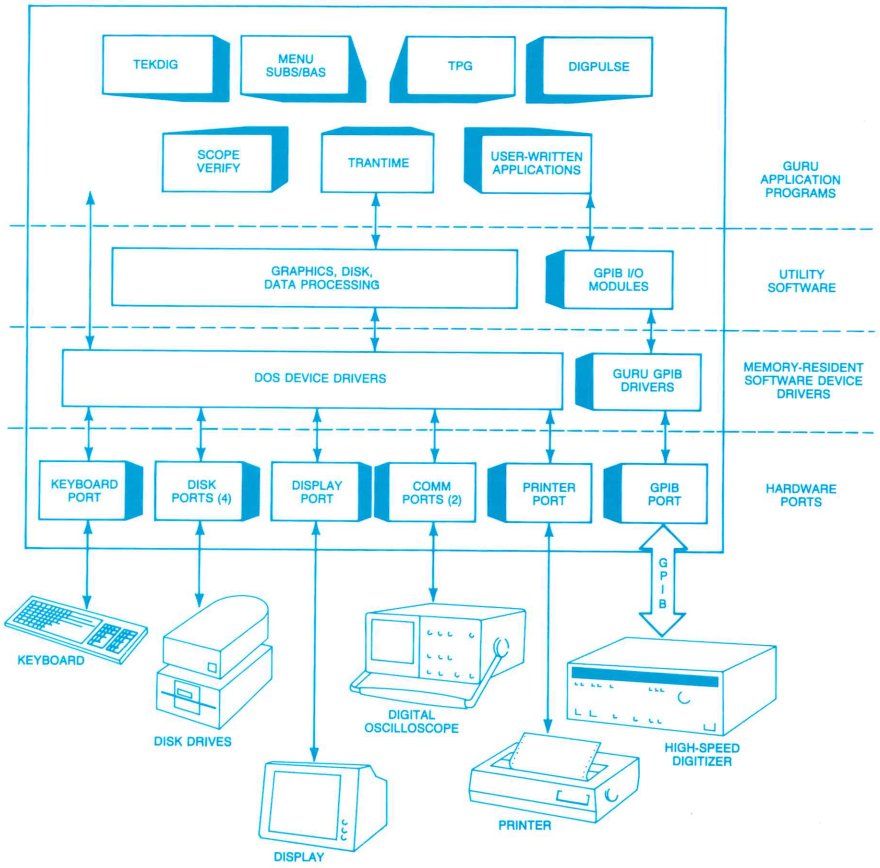


Figure 2. *The PEP 301 comes standard with serial, parallel, and GPIB interfaces, MS-DOS 3.2, GPIB driver and I/O utility software, plus the GURU II application package. GURU II includes six application programs, and the ability to run user-written applications as well.*

existing software applications available for PC-compatible systems. The PEP 301 BIOS has been thoroughly tested with a wide variety of existing software products to guarantee compatibility. For additional details on the BIOS, refer to the sidebar **Compatibility and BIOS.**

Fast memory. The 80386 accesses a full megabyte of 32-bit zero-wait-state RAM via a special extension of the AT bus. This gives greater performance (about 20% greater) while maintaining full AT compatibility. And because we know your growing need for software, this very fast on-board memory will soon be expandable to 16 Mbytes. To assure full performance, a copy of the ROM BIOS is loaded into this zero-wait-state RAM when the system is initialized so BIOS functions are executed at top speed.

An additional 256K bytes of system memory can be configured to conform to the Lotus/Intel/Microsoft EMS (Expanded Memory Standard). This means that when you run packages such as Framework, your PEP 301 won't run out of data space.

Flexible display. The PEP 301 display system is designed to give you high-quality color displays, plus maximum flexibility. The display controller lets you display up to 16 colors simultaneously, selected from a total palette of 64 colors. The 14-inch color graphics monitor is both TTL and analog compatible and supports display modes of up to 800x600 pixel display resolution. It is compatible with (and exceeds) all previous PC display standards, including CGA, EGA, and Hercules. The monitor can be switched to analog mode and independently supports the new IBM VGA standard.

Adjustable clock rate. Some of the toughest bugs to track down are those that result from hidden software time-dependencies. The PEP 301 system clock rate is selectable by system command to 4.77, 6, 8, or 16 MHz. This allows timing-dependent programs written for the PC or PC/XT, for example, to execute on the PEP 301 without timing errors.

Easy configuration menu. The PEP 301 is expandable and configurable. A special menu program, accessible through the keyboard, makes configuring memory or adding disks easy. Other routine functions such as setting the date and time are also included on this menu. Simultaneouosly pressing the CONTROL-ALT-ESCAPE keys on the keyboard pops up a menu (see Figure 3). Other comparable systems require running a program from disk to perform setup operations.

Any items on the menu can be altered and updated. For example, the battery-backed time and date may require change from the factory-set value (U.S. Pacific time zone) to the correct local time. Selecting the date (menu item 1) or time (menu item 2) makes this easy.

If a user replaces the standard hard disk with another type or adds an additional hard disk, menu item 6 is useful for setting up the new disk. Several types of floppy disks are supported including the most commonly used 360 Kbyte format. Item 7 makes disk configuration easy.

Various software packages have differing requirements for memory assignment. Menu items 8 and 9 help you make these memory choices.

Easy GPIB configuration. The PEP 301 includes EZ-BUS — an instrument control programming package that converts many standard MS-DOS programming languages into instrument control languages (see **EZ-BUS — Converting standard languages into GPIB controller languages** in this issue for additional information). This package makes it easy to write instrument control software using many popular programming languages.

Open architecture means easy configuration — and tools!

With the open architecture of the PEP 301, you no longer have to choose between a severely restricted set of instruments and

tools, or extensive development of custom software. The PEP 301 is ideally suited to "mixing and matching" hardware and software from a variety of vendors. There's an increasing industry emphasis on interfacing standards for both hardware and software (in the form of shared data formats and compatible user interfaces).

The PEP 301 controller gives you maximum flexibility, easy system configuration, and the ability to interact with the widest possible range of software and peripheral products. You can run instrument control programs, do spreadsheet applications, track and control projects with project management software tools, create reports and documentation, and connect to a mainframe for number-crunching or access to a large engineering database — all from the same system.

In addition, the PEP 301 gives you access to a rich set of software development tools and third-party applications software. Development tools include Microsoft QuickBASIC, Pascal, Fortran, C, and macro assemblers, as well as Borland International TurboBASIC, TurboC, and TurboPascal. On the applications side, we've tested more than 25 popular test and measurement software packages and verified that they run on the PEP 301. And with tested PC/AT compatibility, you also have access to the hundreds of general-purpose business and professional packages available for the PC market.

Tested and tuned to ensure software compatibility

More and more, engineers involved in almost any measurement environment have to be part-time computer experts. In addition to writing programs in standard languages, you have to be adept at bringing up and running many different software programs "on the fly." This means that software compatibility is a vital piece of your instrument control puzzle. When you load a program and type RUN, you want things to work the first time, every time. When they don't, you waste valuable time troubleshooting software instead of acquiring and analyzing data.

Tektronix has performed extensive software testing to verify that all standard Tekware measurement and analysis packages run reliably on the PEP 301 to give you easy system integration and maximum productivity. Tekware offerings include:

- **GURU II GPIB User's Resource Utility.** Standard on the PEP 301, GURU II lets you configure and control a complete GPIB system from the PEP 301 controller. Includes BASIC routines for common GPIB tasks, a Test Procedure Generator, and five other application programs, plus support for popular Tektronix digitizers.
- **ASYST Software.** A data acquisition and analysis environment with a FORTH-like language. ASYST provides device-independent data acquisition commands, direct array manipulation, and direct reading and writing of Lotus 1-2-3 .WK1 and .WKS files. ASYST also includes drivers for numerous Tektronix scopes and digitizers.
- **SPD Signal Processing and Display Software.** A signal acquisition, processing, and display tool set with 196 functions designed for the PEP 301 and other IBM PC compatibles. A user-friendly menu interface uses function keys and form fillout. Also provided are library interfaces to C and compiled BASIC user programs. Performs Fast Fourier Transforms (FFTs) and inverse FFTs.
- **EZ-TEK 2400 PC Test Procedure Generator.** Aids development of automated test procedures to control Tek 2400-Series portable oscilloscopes.
- **EZ-TEST PC GPIB Test Development Software.** A powerful tool for non-programmers that "learns" routines as they are performed manually from the keyboard or the instrument front panels using a convenient menu structure on the PEP 301 screen. Then, a test program is automatically produced in Microsoft QuickBASIC source code.
- **TekMAP 7854 Time and Amplitude Measurement Software.** Provides interfacing, control, data transfer, and processing functions for integrating the Tektronix 7854 Waveform Processing Oscilloscope with your PEP 301 controller.
- **370 Device Test Software.** Automates pass/fail device testing with the PEP 301 Systems Controller and the Tektronix 370 Programmable Curve Tracer. Device parameter limits are entered in a spreadsheet format. Easy-to-use menus allow generating device test procedures without programming knowledge. This simplifies and speeds design, failure analysis, incoming inspection, device screening, quality-control testing, etc.
- **TekSPANS Software.** Three software packages for Tektronix spectrum analyzers:
  General RF Applications Software Package (GRASP) is a versatile system that allows acquisition, storage, display, and analysis of data acquired from Tektronix 490P- and 2750P-series spectrum analyzers. Measurement routines include Total Harmonic Distortion,

Figure 3. *The PEP 301 uses a convenient menu structure and form fillout for instrument configuration.*

Compatibility and BIOS

Will all the software run? Will the add-in cards work correctly in the PC- or AT-compatible card slots?

These are the most frequent questions asked by Engineers who purchase PC- or AT-compatible clones and add in a GPIB card, among others. Often the results are very good. At other times, however, compatibility problems surface only after considerable time and effort have been invested in the system. Incompatibility is often subtle and hard to discover until too late. Often, hardware vendors take little responsibility for the correct operation of the software.

The key to compatibility is in the Basic Input/Output System (BIOS). The BIOS is software contained in ROM (read-only memory) and is most visible at start up when self-test routines are running and diagnostic and BIOS version numbers are displayed on the screen.

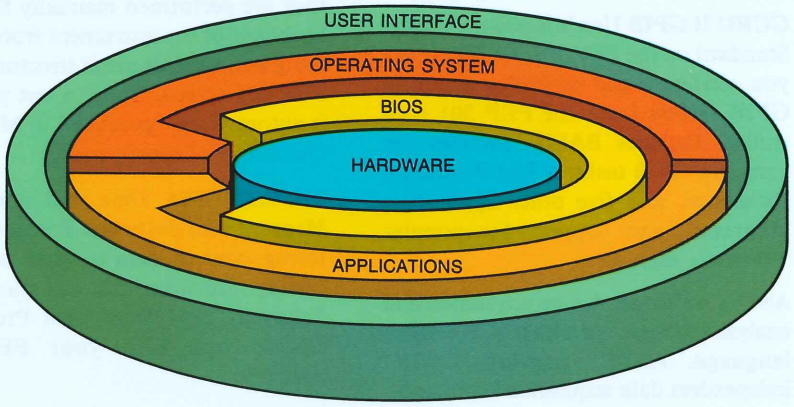
Work of the BIOS doesn't end there, however. As shown in the diagram below, the BIOS is the primary connection between hardware, the operating system, and the users application program. The function of the BIOS is to make using the hardware as painless as possible.

The BIOS allows the program developer to devise programs that access hardware without having to know specific details. For example, a BIOS function call to send a character to the printer or the display relieves the programmer from knowing specific I/O addresses. In effect, BIOS provides device-level control for all the major input and output devices. This separates software from hardware, without extensive overhead or loss of speed. A main advantage is that software developers can create programs that work on a very large variety of machines.

A compatible BIOS makes software run without unexpected results, such as a graphics display with wiggly rather than straight lines, or a total system "lock up." To the user, a compatible BIOS is unseen, regardless of how important it is, because all the user's software runs as expected.

Development of the PEP 301 included extensive third party as well as Tektronix testing of a wide variety of software products, especially all Tekware products. When the unexpected did happen, the problem was isolated to the applicable BIOS functions and the problem corrected. Then, extensive re-testing assured that no new problems were introduced by each change.

The result is a BIOS that is compatible both with Tekware and the wide variety of other software products likely to be used with the PEP 301 Systems Controller.



As shown by this model, the user is isolated from direct interaction with the hardware by succeeding layers of software contained in the Applications Program, Operating System, or Basic Input/Output System (BIOS).

Signal-To-Noise, and Amplitude Modulation. BASIC source code is included at no charge.

Remote Site Monitoring Software (RSM) is a package that simplifies control and data analysis of instruments at remote sites or in hostile environments. While optimized for Tek spectrum analyzers, it can be used with virtually any Tektronix programmable instrument for remote control via phone in Talk/Listen mode.

EMI Prequalification Software provides an economical approach to conducted and radiated EMI testing. Test routines included for FCC Part 15J, VDE 0871, and Mil Std 461B/462.

These and other Tektronix software support packages have been thoroughly tested and verified to run on the PEP 301. For more information on these packages and the instruments they support, refer to **MS-DOS Tekware At A Glance** in this issue.

Backed by Tektronix

With the PEP 301, you get the benefit of Tektronix' years of experience in both stand-alone instrumentation and instrument controllers. Behind the PEP 301 stand oscilloscopes, digitizers, waveform analyzers, and hundreds of other test and measurement instruments of unexcelled quality and price/performance.

For the highly varied world of PC-based instrumentation, the Tektronix PEP 301 provides a powerful, integrated system that represents a solid, lasting investment. Both hardware and software quality are assured by Tek's one-year warranty. And when you need it, there's Tek's outstanding single-point service and support.

We've taken care to ensure that everything — from the PEP 301, to stand-

alone instruments and plug-ins, to measurement software — is tuned to play together. Building a measurement system to fit your specific measurement needs (Figure 4) is made easier. When you buy the PEP 301, you receive on-site installation and a familiarization training session to check out your system and verify that it's running properly. But nobody's perfect, of course. And if perchance your data acquisition package really can't capture the data, you don't have to call half a dozen vendors who never heard of each another. Just call Tektronix at 1-800-TEK-WIDE (800-835-9433) — toll free.

For details...

We're proud to introduce the PEP 301, the world's first 80386 Systems Controller. If you'd like more information about the PEP 301 or associated software and measurement instruments, contact your local Tektronix Field Office or representative. U.S. readers can call the Tektronix National Marketing Center toll free — 1-800-426-2200 — for literature or to place an order. And tell them you read about the PEP 301 in **HANDSHAKE!**

Figure 4. *Add software and a programmable measurement instrument to the PEP 301 for easy configuration of a complete measurement system.*

Program generator or procedure generator — What's best for you?

Two terms are used regularly in describing test development software — test program generator and test procedure generator. While these terms are very similar and the software may appear to do the same job, the results produced and the method of getting those results are quite different. For best measurement results, it's important to buy the software best matched to your measurement application.

A test procedure generator (e.g., EZ TEK 2400 PC) allows you to produce a test routine including automatic instrument setup and customized test specifications. However, it does not generate source code in the process of developing the test procedure. Generally, a test procedure generator is easier to use, particularly for the small test system or the novice ATE user.

A test program generator (EZ-TEST PC) operates in a similar manner to produce a test routine. However, it also produces source code which can be run independent of the program generator. In general, test program generators address a larger variety of system instruments and may include more extensive test development routines. Most test program generator software is very flexible since the source code can be modified to increase execution speed or to add more features. As a result, test program generator software is ideally suited for large, multiple-instrument test systems.

To fit your automatic testing needs, Tektronix provides both types of test development software. For additional details, request the Tekware Software Library Catalog using the **HANDSHAKE** reply card. U.S customers can get information or order software from the National Marketing Center — 1-800-426-2200.

Have you returned your HANDSHAKE survey?

Have you filled out and returned the **HANDSHAKE** survey which was included as the outside cover on the Fall 1987 issue and as a centerfold in the Summer 1987 issue? Purpose of this survey was twofold — first, to be sure that everyone on our mail list wanted to continue receiving **HANDSHAKE** so we are not wasting copies. Secondly, to gather some valuable information from you in order to chart the direction of **HANDSHAKE** for the next few years.

We've already gotten valuable information from those who promptly returned their surveys. However, about half of our readers have yet to respond and let us know if they want to continue receiving **HANDSHAKE**.

If you're one of those who had good intentions to fill out the survey but just let it slip by, dig out those back issues now, fill out the survey, and send it in. If you can't find the survey or if you feel it takes too much time to fill out, just check the **Yes** box on the **HANDSHAKE** reply card in this issue. In either case, please attach the peel-off address label from the current issue as it contains some codes to help us process your response faster.

If for some reason you no longer want to receive **HANDSHAKE**, we'd appreciate if you let us know so we can keep our mail list up to date.

Thank You!

ADIF — The Analog Data Interchange Format

The increasing number of Tektronix digitizers and software packages supporting them causes a problem. How can a user meaningfully combine the data from two or more packages? Until now, there seemed to be no satisfactory method. Simply specifying an ASCII file or spreadsheet format accomplishes almost nothing. These formats don't include information on how to interpret the data or combine it with measurements or plotting information.

Some packages attempt to get around this problem by saving Tektronix Standard Codes and Formats preambles and curves directly on the disk. After all, Tektronix Standard Codes and Formats is a standard, isn't it? Unfortunately Tektronix Standard Codes and Formats is so general that each instrument has its own set of rules on how to interpret and scale the raw data to make a normalized waveform. What's needed is the ability to acquire, store, and transfer data from a variety of digitizers and software packages in a truly standard format.

These were the considerations that led to the development of ADIF, the Analog Data Interchange Format. ADIF (now available from Tektronix) allows for the standardized representation of a wide variety of analog data. This standardization allows all sorts of instruments and programs to make use of ADIF's capabilities. Currently, GURU II (the GPIB User's Resource Utility) writes files in the ADIF format. SPD (Signal Processing and Display programs) can both read and write ADIF data files. This capability allows the use of GURU II as an acquisition front end for SPD. This becomes essential when using digitizers not found in SPD acquisition menus, or when detailed control of the GPIB board is required.

ADIF was designed not only to store acquired waveforms, but also to contain a wide variety of data-related information. Fields available in the ADIF format include measurements, test identification, date and time, etc. Of course, not every program will use every field. When a program finds an unrecognizable field, it can simply ignore it.

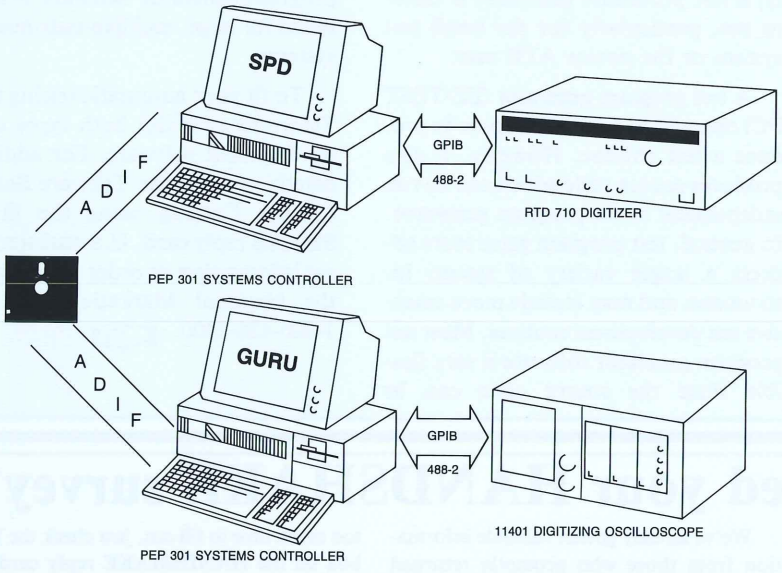
ADIF syntax is compatible with the new IEEE 488.2 standard for GPIB, and is suitable for use with ASCII files. This means that ADIF looks like the output of instruments that conform to the 488.2 standard.

The major differences between 488.2 and ADIF are that ADIF curve and measurement data is normalized, and focuses on data definition rather than instrument control. By normalized data, we mean that ADIF stores data in actual scaled values rather than in 8-, 10-, or 16-bit RIBINARY or RPBINARY digitizer levels. Using scaled data makes it possible to acquire a signal from one instrument with one software package, process it with a second package, and send it to a totally different instrument using a third package.

ADIF's focus on data definition provides an easy means for associating secondary information such as pulse measurements, waveform statistics, etc, with a waveform.

To enable customers to use ADIF in their own programs, Tek is developing a library of ADIF input/output routines that will be available for Microsoft C and QuickBASIC. Also, efforts are currently underway to adapt other Tektronix software packages to the ADIF standard.

The ADIF specification is available from Tektronix. For a copy, check the appropriate box on the **HANDSHAKE** reply card.



Waveform information can be shared between differing software systems or acquisition instruments using the Analog Data Interchange Format (ADIF).

MS-DOS
Tekware At A Glance

Produced by the **HANDSHAKE** Group, Tektronix, Inc.
February 1988

Software Package	Instruments Supported: 2220/21/30 Portable Digital Storage Oscilloscope — GPIB	2220/21/30 Portable Digital Storage Oscilloscope — RS-232	2430/A/32 Portable Digital Storage Oscilloscope	2445A/65A/67 Portable Digital Storage Oscilloscope	336 Portable Digital Storage Oscilloscope	370 Programmable Digital Storage Oscilloscope	371 High-Power Programmable Curve Tracer	390AD Programmable Waveform Digitizer	468 Portable Digital Storage Oscilloscope	490P-/2750P-Series Programmable Spectrum Analyzer	5223 Digital Storage Oscilloscope	7D20 Programmable Digitizer	7250 Transient Digitizer	7612D Programmable Digitizer	7854 Waveform Processing Oscilloscope	7912AD/HB Programmable Digitizer	11301/302 Programmable Analog Oscilloscope	11401/402 Programmable Digitizing Oscilloscope	AA 5001/SG 5010 Programmable Analyzer/Oscillator	CG 5001 Programmable Scope Calibration Generator	DCS01 Digital Camera System	MI 5010 Programmable Multifunction Interface	RTD 710 Digitizer	TM 5000 Programmable Test Instruments	TSI 8150 Test System Interface	Instruments From Other Vendors	Features: Front Panel Control	GPIB Communication	RS-232 Communication	Pulse Parameters	Waveform Analysis	Extended Graphics	Test Procedure Generator	Test Program Generator	Data Logging	ADIF Format	Programming Language Support: Interpretive BASIC	IBM BASIC Compiler	Microsoft QuickBASIC	C Language	Borland Turbo Pascal	FORTRAN
GURU II S3FG100/110	●		●	●	●	●	●	●	●	●	●	●		●	●	●		●	●	●		●	●	●	●	●	●	●		●		●		●	●	●	●					
GPIB Interface Software S3FG120/121/122																												●												●	●	●	●		●
Signal Processing & Display (SPD) Software S3FG130	●	●	●									●			●	●		●			●		●						●	●	●	●	●							●				●
EMI Prequalification Software S26EM00										●																			●					●						●					
General RF Applications Software (GRASP) S26RF00										●																		●	●			●	●			●				●	●				
Remote Site Monitoring Software (RSM) S26RM00/01										●																		●	●			●	●			●				●					
EZ-TEK 2400 S38A101			●	●															●		●		●		●			●	●		●			●		●								
7854 Communications and Control Software S42P101														●														●	●												●				
7D20 Time and Amplitude Software S42P201												●																	●		●	●	●											
7854 Time and Amplitude Software S42P202														●															●		●	●	●			●								
ASYST Ver 2.0 S42P301																												●	●		●	●	●			●								
Digitizer Drivers for ASYST S42P302	●		●									●	●		●	●								●					●		●	●	●											
EZ-TEST PC S45F030	●		●	●		●		●		●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●		●	●		●		●	●	●	●			●				
11400 Utility Software S47P102																	●											●	●	●		●				●					●				
11300 Utility Software S47P103																●												●	●	●		●				●					●				
11400 Driver for ASYST S47P303																	●											●	●	●		●												
370 Utility Software S48P104						●																						●	●				●	●		●					●			
370 Device Test Software S48P401						●																						●	●					●		●								
2220/2230 Instrument Utilities S49Z201		●																													●								●		●			
2220/2230 Instrument Utilities S49Z202	●																												●														●	
2220/2230 Instrument Utilities S49Z203	●																																						●		●			
DCS Menu Software (Available only with DCS01 System)				●											●	●			●												●		●		●								
DCS01 Functional Library S58DC01				●												●			●																						●	●	●	●
DCS/GPIB Driver for 2467 S58DC02				●															●									●	●		●		●		●								
DCS Waveform Acquisition for SPD S58DC03				●												●			●																									
DCS/GPIB Driver for 11302 S58DC04																●			●									●	●		●		●		●								

*For additional information on these Tekware packages, request the Tekware Software Library Catalog on the **HANDSHAKE** reply card.*

How to use this chart

By instrument. Find your instrument in the list at the top of the chart. Follow down the column to identify Tekware packages which support this instrument. Other instruments supported by a particular software package, features provided, and languages supported are given in the row for each software package.

By software package. Find the software package in the list on the left side of the chart. Follow across the row for the instruments supported, features provided, and languages supported.

By features provided. Follow down the column for the feature of interest to identify Tekware packages with this feature. Instruments supported, other features, and languages supported are given in the row for this software package.

By language supported. Follow down the column for the programming language to identify Tekware packages that support this language. Instruments supported, features provided, and other languages supported are given in the row for this software package.

Some definitions . . .

Here are definitions for some of the terms used in the Tekware chart:

Instruments from other vendors — Supports instruments from other vendors that comply with the IEEE-488 Standard.

Front panel control — Front-panel settings of associated instruments can be read and/or set.

GPIB communication — Data can be sent and received via GPIB.

RS-232 communication — Data can be sent and received via RS-232.

Pulse parameters — Can perform pulse measurement functions such as risetime, falltime, width, etc.

Waveform analysis — Can perform waveform operations such as FFT, convolution, etc.

Extended graphics — Supports graphics cards with resolution higher than CGA (e.g., EGA, VGA).

Test procedure generator — Produces a test routine that requires the original program to run.

Test program generator — Produces a test routine and also produces source code which can be run independent of the original program.

Data logging — Data or results can be stored to disk or other peripherals.

ADIF format — A Tektronix format for interchange of waveform data between instruments.

Programming language support — Produces source code or object files which can be read by the specified languages.

EZ-BUS — converting standard languages into GPIB controller languages

Dave Barnard
Personal Engineering Products Marketing
Portable Instruments Division
Tektronix, Inc.

Designers and builders of ATE systems soon realize that the total cost of a measurement system includes much more than just the cost of hardware. A large, and often difficult to predict, cost goes into developing, debugging, and maintaining the system software. Many times, this cost exceeds the total cost of system hardware.

There are risks involved with your choices of system software and it's important to understand these risks early in the project. For example, if system design gets stalled, it may adversely impact time-to-market of a new product or it may hold up production output plans for existing products.

To reduce software development costs and minimize these risks, system designers are turning to standard software tools in place of custom-designed tools. This reduces overall development time as well as the learning time required.

Since the birth of the IBM PC, over 12 million PCs (or compatibles) have been installed. The pervasiveness of PC-based architecture and the MS-DOS operating system have resulted in a wide and ever growing variety of software. Programs are available for everything from business to engineering applications.

Developing test system software based on such a generic hardware/operating system environment is very inviting. But there have been a few problems. Just one of these problems has been the lack of built-in instrument control commands which system designers have come to expect with dedicated controllers.

For example, using the original interpreted BASIC — BASICA to connect to a GPIB port is complex. Special techniques are required to link and load custom-written device drivers, and special assembly routines must be invoked using the CALL command. Accessing GPIB becomes a complex programming task. An example program is shown in Figure 1.

Simply sending a single command, even after connecting to the bus, can require three lines. Set-up parameters must be preloaded into variables as shown in Figure 2.

Tektronix EZ-BUS for the PEP 301 Systems Controller was developed to solve these problems. With EZ-BUS, instrument control becomes much easier and much more familiar to the programmer.

Simple to get started

To initialize the system, simply type EZ-BUS at the MS-DOS prompt. This reads the instrument configuration file including addresses and other needed parameters.

To begin programming in the desired language, the next step is loading your favorite compiler. With Microsoft QuickBASIC, for example, this is done by typing QB. This brings up the editor screen (see Figure 3). Now, the system is ready for you to begin programming.

EZ-BUS works with BASIC and C

Commands from EZ-BUS become part of the programming language you are using. BASIC compilers supported include Microsoft QuickBASIC and Borland Turbo BASIC. C Compilers supported include Microsoft C and QuickC, and Borland Turbo C.

EZ-BUS commands remain the same regardless of whether you are using C or BASIC. Once you learn the EZ-BUS commands, you don't have to learn a new set of commands when changing languages.

```
list 1-50
 1  CLEAR   ,58400!
 2  IBINIT1= 58400!
 3  IBINIT2= IBINIT1 +3
 4  BLOAD "bib.m",IBINIT1
 5  CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,IBRSC,IBS
RE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF,IBTRAP)
 6  CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,IBRDA,I
BSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,IBSTA%,IBERR%,IBCNT%
)
 7  INIT = IBINIT1+ 1200
 8  BLOAD "bib728.m",INIT
 9  CALL INIT(EMBLK,DEBLK)
10 '-----------------------------------------------------------------
11 ' for compiled version, remark lines 1-9 and
12 ' remove remark (') from the following line
13 'COMMON IBSTA%,IBERR%,IBCNT%
14 COMPILE%=0 ' set to 0 for interpreted BASIC or -1 for compiled BASIC
35 '-----------------------------------------------------------------
40 ' DIGPULSE.BAS - a general purpose digitizer data acquisition program
45 'Copyright (c) 1985,86,87 Tektronix, Inc. All rights reserved.
50 '-----------------------------------------------------------------
Ok
1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF 9KEY 0SCREEN
```

Figure 1. *Programming for instrument control using BASICA is a complex task requiring many lines of code.*

```
list
1000 SCOPE%=1  'set scope address to integer = 1
1010 INQ$="id?"  'set inquire string = "id?"
1020 CALL IBWRT(SCOPE%,INQ$)  ' send id?
1030 CALL IBRD(SCOPE%,ANS$)  ' read in answer
Ok
1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF 9KEY 0SCREEN
```

Figure 2. *Using BASICA, even simple commands may require three lines of code to load parameters into variables.*

Easy configuration

The configuration file stores information about the instruments in the system. This file is easily modified to change instrument addresses or add or delete instruments. Since it's a simple character file, almost any program editor can be used. For example, QuickBASIC has a program editor that can be used very effectively to modify the configuration file, or to create additional files. If configurations are frequently changed, the flexibility of EZ-BUS allows changes in seconds rather than minutes.

To invoke a new configuration, either re-activate EZ-BUS or use the CONFIG command. The CONFIG command can even be used from within a program. Figure 4A shows typical format of the CONFIG command.

The most recent configuration file is saved. When the system is restarted, the latest configuration file is used. As a result, returning to the setup used in the previous session is simple.

A significant benefit of how EZ-BUS works with the configuration file is the way instruments are named and addressed. Pseudo names are used in the program — for example, SCOPE1. Necessary details about the instrument are stored in the CONFIG file and can be easily changed. Your program only needs to refer to the instrument by name — EZ-BUS takes care of the details. As a result, the program itself is straightforward and uncluttered by all the details of interfacing.

GPIB and RS-232 support

Most test instruments have either RS-232 or GPIB interfaces. With EZ-BUS, interface commands are transparent when viewed from within the programs you write. The choice of interface is just another variable in the configuration table. This means that if your system calls for using the same type of instrument with both a GPIB and RS-232 interface, the program looks the same for both. The configuration file accommodates the differences.

Powerful but simple commands

EZ-BUS adds 15 additional commands to your programming environment. For most work, only two are used, but the rest are there when you need them. The most frequent operations involve sending commands to an instrument, and reading measurement results or control settings from the instrument. EZ-BUS does this with two commands — ISEND and IREAD.

For example, to send a command to a 2432 which has been set up in the configuration table as SCOPE1, use the ISEND command as shown in line 120 of Figure 5 (shown in QuickBASIC). Control settings can be read using IREAD as shown in line 110 of Figure 5.

Notice that unlike the earlier example in Figure 2, all the information is contained on one line. This makes programming easier, resulting in faster programming and less costly maintenance.

Send and receive with flexibility of programming

In the previous example, the message to the instrument was a constant, or literal, character string enclosed in quotes. Source or destination of messages or data between the instrument and the PEP 301 System Controller can be either program variables or disk files.

This choice can save time and add flexibility. For example, all front-panel settings for an instrument can be placed in a disk file using the command shown in Figure 4B. The settings can be restored later using the command in 4C.

If the instrument is set to send and receive front-panel settings in ASCII format, the files become readable ASCII files. This means that command files can be edited and stored on disk. Since the disk drive can be specified in the command, you can read files from a floppy disk. This makes it possible to change the command settings by inserting a different floppy disk while running the same program.

As a result, actual setting information and measurement data can be changed or replaced separate from the program (and the physical controller) itself. The programmer may not need to have any access to measurement data or settings. In some applications involving proprietary data, this solves some major hardware and software problems.

When more conventional programming is used, settings and data can be brought into the program as named variables and operated on as usual.

A few more commands to simplify special requirements

EZ-BUS provides some additional commands to allow certain operations to be done easily. For example, the COOKSTRING command shown in Figure 5, line 150 converts the waveform data stored as a string variable into a numeric array. This saves writing a program to extract the data — a process which can be tricky. If the waveform is sent with two bytes per point, your program must know how to put the

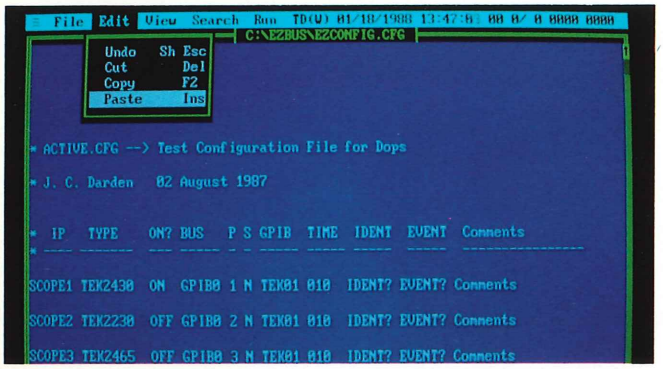


Figure 3. *Instrument configuration is stored in a configuration file which can be edited with most program editors.*

A. The CONFIG command:

```
CALL CONFIG ("C: \ezbus\config1.cfg")
```

B. Reading instrument front-panel settings:

```
CALL IREAD ("SCOPE1","SET?","C:\SETUP1.CMD")
```

C. Restoring instrument settings:

```
CALL ISEND ("SCOPE1", "C:\SCOPE1\SETUP1.CMD")
```

Figure 4. *Examples using EZ-BUS commands.*

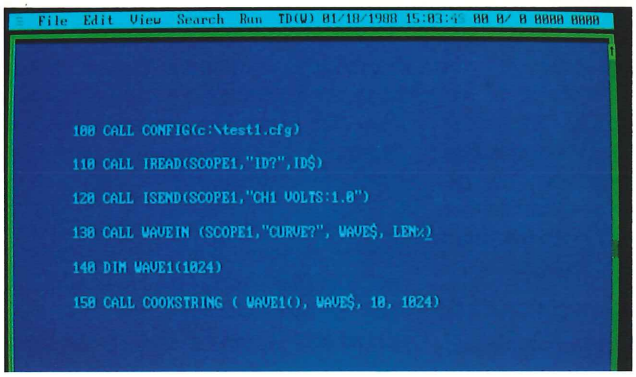


Figure 5. *Example instrument control program.*

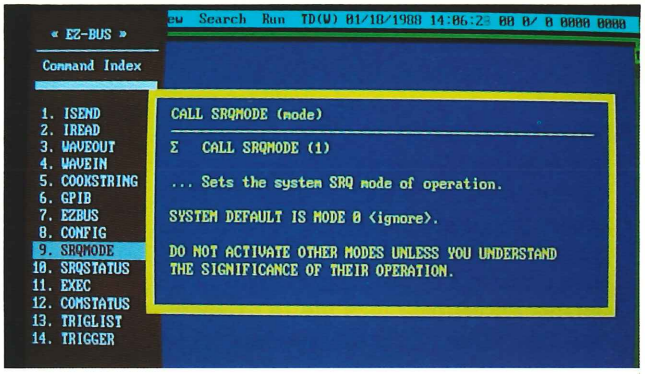


Figure 6. *EZ-BUS help screen can be accessed at any time.*

data into a complete number. COOKSTRING can use an additional parameter (not shown in example) to determine how the information is to be processed. The effect for users is to make programs run faster and eliminate extra programming.

Use DMA when speed is important

For applications using high-speed digitizers to send long blocks of data, a little extra speed may be desirable. Compute-intensive programs with little time to spare can benefit from waveform transfer mode using direct memory access (DMA).

The commands for sending waveforms to or from an instrument are shown in line 130 of Figure 5.

What about interrupts

Some programs never need to worry about interrupts. However, most measurement system programs must know how to handle them. In GPIB applications, interrupts may even be an important part of the overall system design. For example, a DUT test failure might be signaled by an interrupt; otherwise everything is OK.

However, system design is easier and faster if interrupts can be turned off during the early phases of software development. EZ-BUS has four software-selectable interrupt modes to make programming flexible to fit your needs.

The default mode, **Mode 0**, ignores all interrupts. This is useful when trying out a section of a new program and you don't want changes in program flow due to an instrument service request (SRQ).

Mode 1 clears the instrument's SRQ. No special programming is required to clear the indicator light on the instrument front panel — EZ-BUS automatically tells the instrument to clear its SRQ.

Mode 2 reads the interrupt information and puts it away in a first-in-first-out stack. Your program can get the information and act upon it when appropriate.

Mode 3 activates a program branch. You can use this to cause a change in program flow when an external SRQ occurs. This allows a "real time" mode to quickly respond to external events.

Plenty of help — just a keystroke away

Software developers have enough to do! Digging through a variety of manuals can be frustrating, particularly when you're trying to solve an immediate problem.

But EZ-BUS has a better way! By pressing the ALT-X keys simultaneously, you can activate the help screen (see Figure 6). Help is provided for each EZ-BUS command along with the syntax format for that command. The help screen can be called up any time you need details on how to use an EZ-BUS command. When you have the information you need, press ESC to clear the help display and return to where you left your program.

A window on the interface

One of the first things you may notice on the display when using EZ-BUS is the addition of some characters in the upper right corner of the screen. This character display is referred to as the "peephole." Some of the information it provides is described in Figure 7.

If the peephole display interferes with your application, it can be turned off.

There's more ...

Although we've discussed only a few of the features available in EZ-BUS, you should have a good idea of what it can do. EZ-BUS is available only as an integral part of the PEP 301 Systems Controller and is not available separately. For additional information, request the PEP 301 information using the **HANDSHAKE** reply card. U.S. readers can call 1-800-246-2200 for additional information.

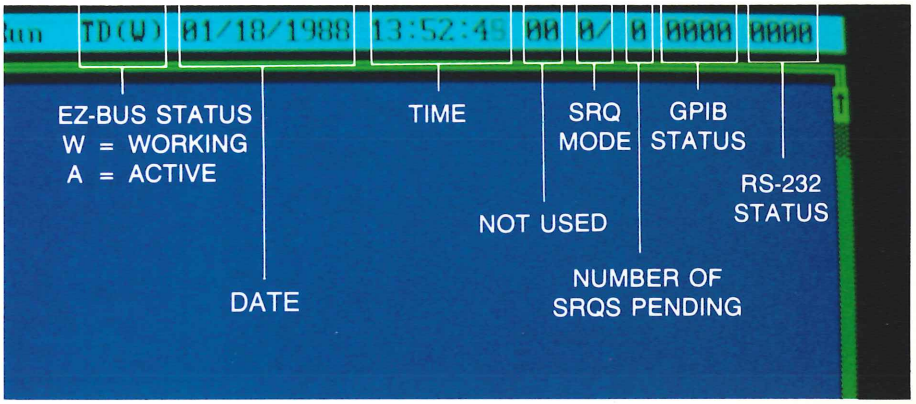
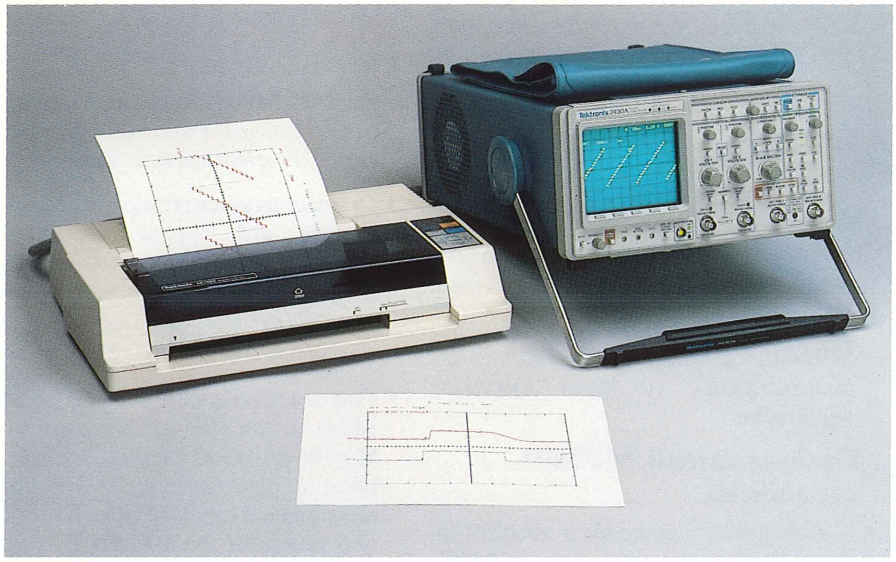


Figure 7. *The "peephole" provides a window on the interface to monitor system status.*

The HC100 — Perfect companion for Tektronix digital storage oscilloscopes



The HC100 Color Plotter provides four-color output of waveform plots and setup information from most Tektronix Digital Storage Oscilloscopes.

Now there's a perfect companion for providing output from Tektronix digital storage oscilloscopes (DSOs) and other instruments with plotter outputs. The new Tektronix HC100 Color Plotter is a low-cost, four-pen, color plotter that can provide direct output of waveform plots and setup information from most Tektronix DSOs. It can be operated as a general purpose plotter, allowing mixed graphics and text, or as an Epson-compatible printer. A full ASCII 96-character set is provided for text output. International character sets for 11 countries can also be selected.

Acquired waveforms from the digital memory of the instrument, as well as DSO setup conditions, are output directly to the HC100. Plot output is controlled from the front panel or keyboard of the instrument. Up to six waveforms in X-T format (amplitude vs time) can be contained in a single plot, depending upon instrument model and memory capacity.

The HC100 comes standard with both a GPIB and Centronics interface, although only one interface can be attached to an instrument at a time. Optional cables are available to attach the plotter to your instrument.

The HC100 is compatible with any instrument that uses Hewlett-Packard Graphics Language (HPGL). It operates in a manner similar to the HP7470A plotter.

Both graphics and text can be printed in color. Three types of pens are available: Fiber-tip pens with water-based ink for paper, fiber-tip pens with oil-based ink for overhead projection film, and ball-point pens with water-based ink for paper. Ball-point pens produce the finest line. Each pen set includes four colors: Black, red, green, and blue.

INSTRUMENTS THAT INTERFACE TO THE HC100

- 336 Digital Storage Oscilloscope w/Option 01
- 370 Programmable Curve Tracer
- 371 Programmable Curve Tracer
- 468 Digital Storage Oscilloscope w/Option 02
- 2220 Digital Storage Oscilloscope w/Option 10
- 2221 Digital Storage Oscilloscope w/Option 10
- 2230 Digital Storage Oscilloscope w/Option 10
- 2430 Digital Oscilloscope
- 2430A Digital Oscilloscop (Version 1.8 Firmware or above)
- 2432 Digital Oscilloscope
- 7854 Oscilloscope
- 7D20 Programmable Digitizer
- RTD 710 Digitizer

Figure 1. *Tektronix instruments supported by the HC100 at the time this article was written.*

The HC100 pen cartridge holds four pens. Pens of different colors, ink types, or point styles can be mixed in a pen cartridge. The pen cartridge is easily changed, allowing the user to quickly change colors or pen types. The plotter also has an automatic capping feature which extends the life of the pens.

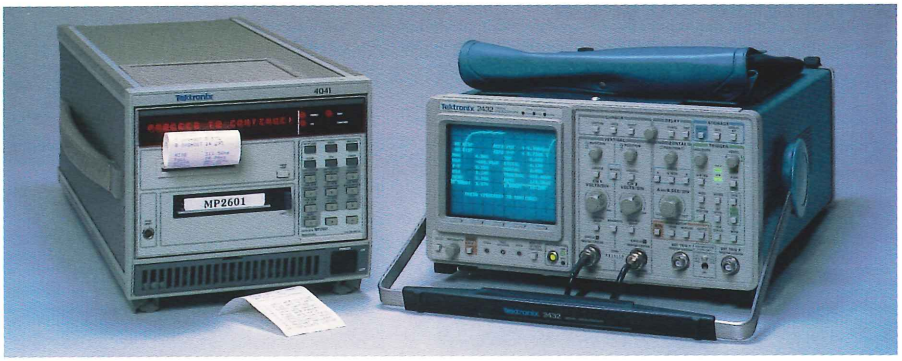
The HC100 is not recommended to be used with a GPIB instrument and an external controller. It works best when directly attached to the instrument to avoid handshaking problems.

For more information

To order the HC100, U.S. customers may call the Tektronix National Marketing Center toll free — 1-800-426-2200. Or contact your local Tektronix Field Office or representative. And tell them you saw it in **HANDSHAKE**.

For a data sheet on the HC100, check the box on the **HANDSHAKE** reply card in this issue.

MP2601 acquisition capabilities expanded



The MP2601 Portable Measurement Package shown with the 300 MHz 2432 Digital Storage Oscilloscope.

The Tektronix 2432 Digital Storage Oscilloscope (DSO) is now available as an option to the MP2601 Portable Measurement Package (available as MP2601 Option 1S). The 2432 provides extended bandwidth for repetitive signal acquisition to 300 MHz (see sidebar **Introducing the 300 MHz 2432 Digital Storage Oscilloscope** for additional details on 2432 performance). This allows the MP2601 to address an even greater range of applications.

MP2601 capabilities

The MP2601 system enhances and extends the performance of the 2430 family of DSOs by providing the following capabilities:

- Portable data logging and recall of waveforms from files for developing and examining waveform data histories.
- Event capture mode to allow "baby sitting" operation for logging waveforms on either a trigger event or when the data exceeds predefined boundaries.
- Waveform parameter extraction similar to that provided by the 2430A and 2432 (see Figure 1), but with higher resolution for both time and amplitude measurements (based on linear interpolation). Waveform parameters can be determined on either waveform data from the DSO or from data that has been logged to a file.
- Extensive set of waveform mathematics from waveform addition to FFT analysis (see Figure 2).
- Custom applications with the application program selection. Routines are provided for propagation delay and energy measurements with room for user-developed routines. Since there are a variety of ways to make measurements depending on the application, the MP2601 allows users to tailor measurements to their specific application.

Options extend MP2601 capabilities

A number of options are available to increase the functionality of the MP2601. These options offer a means to "design" a system that most closely fits the needs of your application.

- **Disk drive (Option 29)** adds three capabilities: 1) Storage of additional waveforms, 2) Storage of instrument settings, 3) Ability to create a library of write-protected reference waveforms for use in the event capture mode.
- **Graphics terminal (Option 32, 35, or 36)** coupled with applications software S49Z116 (234X Waveform Analysis Version 3.1), adds additional analysis capabilities with graphic output of waveforms and analysis to the terminal.
- **Program development ROMs (Option 30)** added to the 4041 allows users to: 1) Modify programs to meet specific application requirements, 2) Add specific measurement capabilities to the application section of the MP2601.

  NOTE: Tektronix Application Engineers are available under the Technical Assistance Services program to help in program development efforts.
- **HC100 Plotter (Option 1H)** allows hard copy of information (waveforms, text, and analysis results) from the DSO screen.

These are a few examples of how the MP2601 options can be used to further match MP2601 performance to the requirements of your application. Other options are available; see the Tektronix Product Catalog for details.

MP2601 Waveform Parameter Extraction

Maximum Amplitude
Minimum Amplitude
Peak to Peak
RMS
Middle Value
Mean Value
Top Level
Distal Level
Mesial Level
Proximal Level
Base Level
Top Overshoot
Base Overshoot
Area
Risetime
Falltime
Width
Duty Cycle
Period
Frequency

Figure 1. *Waveform parameters that can be extracted by the MP2601.*

MP2601 Waveform Mathematics

Add Waveforms
Substract Waveforms
Multiply Waveforms
Divide Waveforms
Scalar Add
Scalar Multiply
FFT
Correlation
Integrate
2-Point Differentiate
3-Point Differentiate
Smooth

Figure 2. *Waveform mathematics functions provided by the MP2601.*

Some typical MP2601 applications

Since its introduction in 1985, the MP2601 has been used in a wide and increasing range of applications. The MP2601 was designed to extend the capabilities of the 2430 family of DSOs and, as such, finds usage in a number of different applications. Here are several application areas where addition of the 2432 to the MP2601 will provide increased measurement capabilities.

- **Digital semiconductor and board testing.** The MP2601 provides the basis for adding analog waveform acquisition and measurement capability to digital semiconductor and board test systems. The MP2601 acquires and analyzes measurement data and provides answers to the test system.
- **Automated telecommunication measurements.** The MP2601 can automate telecommunications tests, especially "T1" and "T3" carrier testing. A routine to support these measurements is available for addition to the application section of MP2601 System Software. With the increased bandwidth of the 2432, the MP2601 can address additional requirements in this area.
- **Long term event monitoring.** Using the event capture mode along with the data logging capability, the MP2601 can be used to monitor and capture long term events. This has found application in power source and power distribution monitoring applications as well as a means of identifying intermittent problems in equipment or systems.

Many more applications exist for the MP2601 than can be described here. If your application calls for data logging, waveform parameter extraction, or waveform calculations in a portable measurement environment, the MP2601 may be the answer to your measurement needs.

Want to know more?

To see how the MP2601 with either the 2430A or the 2432 DSO can fit your measurement needs, contact your local Tektronix Field Office or representative. Or check the appropriate box on the **HANDSHAKE** reply card in this issue for product literature.

Introducing the 300 MHz 2432 Digital Storage Oscilloscope

The new 2432 Digital Storage Oscilloscope (DSO) builds upon the base developed by the 2430 and the 2430A (see **The 2430A — full measurement automation in a portable digital oscilloscope** in the Summer 1987 **HANDSHAKE**), and adds extended bandwidth, faster sweep speed, and additional capability to the "Save-on-Delta" function.

New features provided by the 2432:

- Equivalent time acquisition to 300 Megahertz for repetitive signals
- 2 Nanoseconds/division maximum sweep rate (40 picoseconds/point, 25 Gigasamples/second) for repetitive signal acquisition
- Averaging before "Save-on-Delta" comparison

In addition, the 2432 maintains the features which have made the 2430 and the 2430A the standard for portable measurements:

- 100 Megasamples/second dual channel single-shot acquisition
- 8 Bit vertical resolution
- Selectable 1 Megohm and 50 ohm input impedance
- Auto Setup for automatic single-button setup of timing, trigger, and scaling for single or dual channel on any unknown signal
- Local Test provides a linked series of instrument setups, acquisitions, and waveform measurements
- Waveform Parameter Extraction for flexible and automated measurements of time and amplitude information from waveform data
- Setup Storage retains instrument settings in on-board memory
- Sophisticated triggering including options for video and word recognizer
- Waveform averaging
- Envelope mode operation for long-term monitoring of changes in waveforms
- "Save-on-Delta" to save waveforms that exceed a predefined waveform shape
- Glitch capture of events as short as 2 nanoseconds at all sample rates
- Hard copy output of screen display to plotter or printer
- Portable and rugged instrument
- Full GPIB programmability
- AutoStep Sequencer to save and recall front-panel setups, user prompts, test procedures, and associated I/O actions

As a result, the 2432 offers increased performance and capability for repetitive signal acquisition and measurement. The higher repetitive signal bandwidth provided by the 2432 increases the applications addressable by the 2430 family of Digital Storage Oscilloscopes.

The 2432M for MATE/CIIL

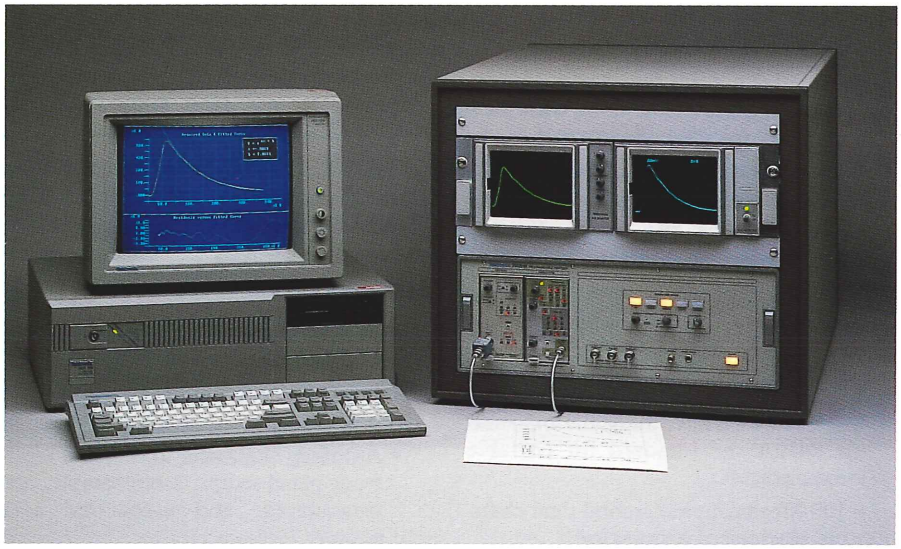
Concurrent with the 2432 introduction is introduction of the 2432M. The 2432M provides all of the features of the 2432 in a MATE/CIIL environment to address the requirements of military and aerospace ATE requirements.

For more information

To find out more about the 2432 Digital Storage Oscilloscope and its built-in measurement and automation features, check the appropriate box on the reply card in this issue. U.S. customers can call the Tektronix National Marketing Center toll free — 1-800-426-2200. Or contact your local Tektronix Field Office or representative. And be sure to tell them you saw it in **HANDSHAKE**.

Transient capture and analysis using the 7912HB and ASYST

Mike Wadzita
Applications Engineer
Instrument Systems Integration Division
Tektronix, Inc.



The Tektronix transient capture team — a 7912HB Programmable Digitizer with 10-picosecond/point resolution and 750 MHz bandwidth, the PEP 301 Systems Controller with 16-MHz speed, and ASYST software for easily integrated analysis power.

Analytic research has two key aspects — being able to capture data reliably, and being able to analyze it efficiently. In many instances, these processes are well established and readily accomplished. In just as many cases, however, the capture and analysis process can be difficult at best, and even uncharted when approaching advanced topics.

With the right tools, even the most commonplace analyses can become far more efficient. More importantly, new areas of study can be approached with the flexibility and power to avoid time consuming or misleading data capture and analysis pitfalls.

But what are the right tools?

The answer, of course, varies with the particular application. But there are some fundamental attributes that need to be considered for most applications. These are:

- Sufficient capture resolution and accuracy to cover critical waveform details. Without sufficient data, analysis falters or becomes misdirected.
- A reasonable degree of automation to simplify setup and ensure measurement process repeatability. Reducing the number of manual steps involved reduces human variability and error.
- Powerful analysis tools that integrate easily with the data capture process. You want to spend your time analyzing data, not integrating instrumentation.

To put these attributes into concrete terms, let's examine a specific application — fluorescence decay — using some specific instrumentation. However, any transient capture application — EMP testing, time-of-flight spectrometry, high-voltage discharge, or laser pulsing, to name a few — can just as easily benefit from the same approach. In fact, many of the program segments presented later in this discussion are general enough to apply to any of these or many other applications.

Fluorescence decay — a test case

The analysis goal of the fluorescence decay example is to fit an exponential curve, of the form $Y = e^{ax + b}$, to the acquired data. This is shown in Figure 1, where the top display shows the fitted curve overlaid with the acquired decay data. The bottom display provides a "goodness of fit" check by plotting residuals versus the fitted curve.

For this example, the Tektronix 7912HB Programmable Transient Waveform Digitizer is used for fluorescence waveform capture. For raw capture power, the 7912HB provides a 750-MHz analog bandwidth and uses a scan-conversion method for 9-bit waveform digitizing with 10-picosecond/point resolution. This is further enhanced with built-in processing, such as average-to-center trace, and full programmability when used with the 7A29P vertical amplifier and 7B90P time base plug-ins. For further information, see **7912HB — Real-time digitizing to 750 MHz** in the Spring 1987 **HANDSHAKE**.

The 7912HB covers the first analysis consideration — sufficient capture capability — and part of the second consideration — automation for setup simplification and measurement repeatability. The ASYST

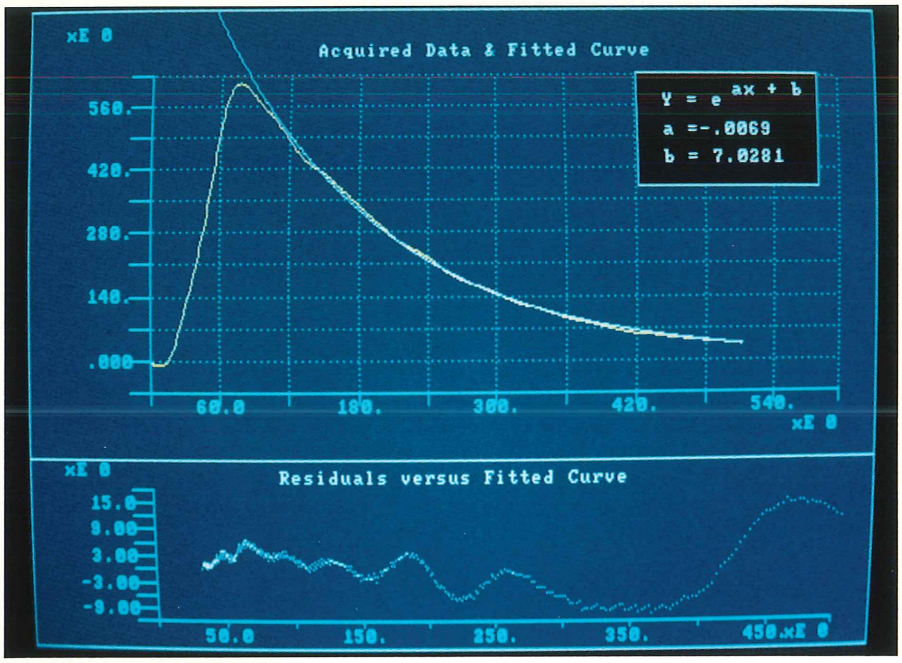


Figure 1. *A fluorescence decay curve fitting example using the Tektronix 7912HB for high-speed transient capture and ASYST software for instrument control and data reduction.*

Scientific Software package, Tektronix S42P301, carries this capture capability forward with powerful instrument control and data analysis features (see **Get an assist in your signal processing measurements** in the Fall 1986 **HANDSHAKE**). ASYST integrates easily with the Tektronix 7912HB Programmable Digitizer, resulting in a strong capture and analysis team.

To complete the team, the entire 7912/ASYST combination takes advantage of the power and economy of being personal-computer based. It runs on the Tektronix PEP 301 Systems Controller or any of the IBM-PC series (or compatibles). GPIB interfacing is provided by the Tektronix GURU II (GPIB User's Resource Utility) card. Although GURU II is available as a complete GPIB interfacing solution in one package (software, manual, GPIB cable, and GPIB interface card), only the interface card is used here since ASYST has its own GPIB drivers.

This data capture and analysis system is quite simple to implement as shown in Figure 2. Figure 3 provides a flow diagram of the complete acquisition and processing operation for exponential decay curve fitting.

Some ASYST background

ASYST is a word definition oriented language. It has about 920 predefined words that perform a wide range of functions from instrument control to data analysis and graphic display of results. For example, MATRIX.INV performs a matrix inversion. A single ASYST command replaces what would take many lines of code in general-purpose languages such as FORTRAN or PASCAL.

There is an even more powerful attribute, however. This is the ability to define your own ASYST words for specific instrument control or application tasks. For example, ACQ.ATC is an instrument specific word that defines automatic acquisition of average-to-center-trace (ATC) data from the 7912AD/HB. Once defined, ACQ.ATC is all you need to know for acquiring ATC data from a 7912AD/HB. It can be used as a single word anywhere in subsequent applications to provide ATC acquisition.

Or ACQ.ATC can even be assigned to a function key on the system controller by the following ASYST statement:

```
68 FUNCTION.KEY.DOES ACQ.ATC
```

In fact, the entire fluorescence decay curve fit shown in Figure 1 can be assigned to one or more function keys. For example, use F1 to perform data acquisition and analysis, F9 to erase the command area from the screen, and F10 to copy screen graphics (e.g., Figure 1) to a printer. The corresponding ASYST statements for these assignments are shown in Figure 4.

The obvious benefit is that a potentially complex waveform capture and analysis task is reduced to pressing a few function keys. Repeated fluorescence decay analyses can be done quickly and efficiently. And results can be just as quickly and efficiently documented on paper. This means less time spent on instrumentation and

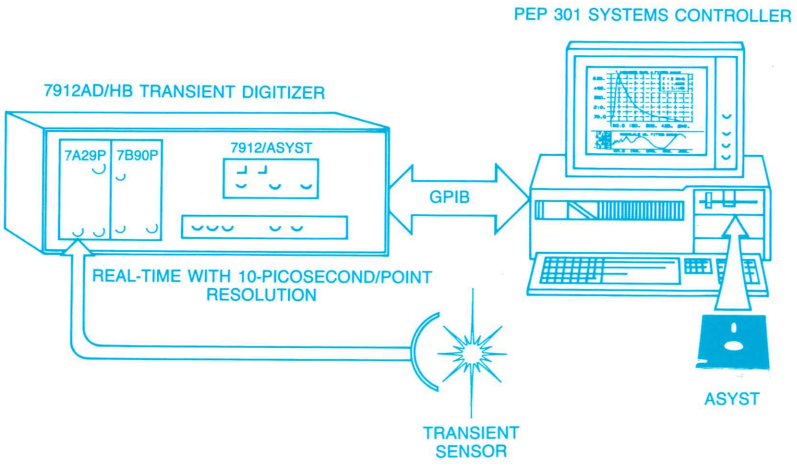


Figure 2. *System economy and efficiency are enhanced by using a PEP 301 System Controller with a GURU GPIB controller card. In many instances, entire data capture and analysis sequences can be reduced to pressing one or two function keys.*

measurement procedures, leaving more time for actual research.

Still another benefit of ASYST is that entire applications, such as ANALYZE.EXP.DECAY can be referred to as a word by other larger applications.

A closer look at ASYST

To get a feel for some of the power of the ASYST/7912HB combination, let's take a closer look at ANALYZE.EXP.DECAY. This ASYST word definition is listed in Figure 5 with comments for line-by-line explanation.

The colon preceding ANALYZE.EXP.DECAY designates the word being defined. The words following ANALYZE.EXP.DECAY comprise the full definition (comments are denoted by a backslash). The end of the definition is indicated by the semicolon.

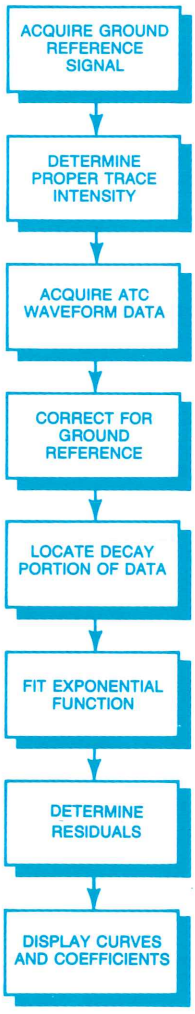


Figure 3. *Flow diagram of the complete acquisition and processing operation for exponential decay curve fitting.*

```
59 FUNCTION.KEY.DOES ANALYZE.EXP.DECAY
67 FUNCTION.KEY.DOES SCREEN.CLEAR
68 FUNCTION.KEY.DOES SCREEN.PRINT
```

Figure 4. *ASYST statements to assign functions to function keys.*

Notice in the definition listing that the operations from "GRAT OFF" DIG GPIB.WRITE to "MODE TV" DIG GPIB.WRITE are fairly generic for 7912AD/HB waveform acquisition. They could just as well be used to define another word — GET.HB.WFM for example. This definition could then be used for general waveform acquisition with the 7912AD/HB in any other application. The only restriction of course is that newly defined words (any series of characters, single words, or combination of words joined by periods) be unique from any previously defined words that you wish to preserve.

The other words in Figure 5, FIND.DECAY.START through CURSOR.OFF, perform curve definition and fitting tasks, residuals computation, and graphic output of results. Still further analysis could be provided by adding appropriate ASYST words after CURSOR.OFF.

Word definitions

In looking at the word definition in Figure 5, you may have noticed that it includes ACQ.ATC. As mentioned previously, ACQ.ATC is by itself another user-defined word created for a specific 7912AD/HB activity (acquisition of average-to-center-trace data). There are a number of other such sub-definitions shown in Figure 5.

For example, AUTO.INTENSITY is a routine designed specifically to automatically adjust the intensity of the 7912AD/HB for optimum scan-capture of the waveform. Another example is GET.GND.LEVEL for automatic acquisition of ground reference data.

Both AUTO.INTENSITY and GET.GND.LEVEL take care of instrument details that are critical to the validity of waveform acquisitions. Yet, these details are often overlooked in manually oriented measurement procedures. Inclusion of AUTO.INTENSITY and GET.GND.LEVEL as part of an ASYST/7912 acquisition routine, eliminates the possibility of setup oversights.

You can use these and other word definitions from the fluorescence decay curve fitting application as part of your own ASYST routines. The sidebar entitled **7912/ASYST signal acquisition routines** provides a listing of some of the more important routines used in this application program along with line-by-line annotation and an expanded description of the activities performed by each routine.

```
:  ANALYZE.EXP.DECAY
    " GRAT OFF" DIG GPIB.WRITE      \Make sure the graticule is off
    GET.GND.LEVEL                   \Acquire ground reference
    AUTO.INTENSITY                  \Adjust the trace intensity
    ACQ.ATC                         \Acquire the decay signal
    GND.LEVEL -                     \Reference to ground
    2 /                             \Correct for factor of 2 from ATC
    WFM :=                          \Save it
    " MODE TV" DIG GPIB.WRITE       \Switch 7912 to video display
    FIND.DECAY.START                \Locate beginning of data of interest
    START.INDEX :=                  \Save it
    COMPUTE.CURVE                   \Perform the curve fit
    COMPUTE.RESIDUALS               \Determine the difference
    GRAPHICS.DISPLAY                \Switch to graphics display
    DISPLAY.DECAY                   \Display acquired data & fit curve
    DISPLAY.RESIDUALS               \Display residuals curve
    DISPLAY.COEFS                   \Display coefficients of fit function
    CURSOR.OFF                      \Blank the graphics cursor
```

Figure 5. *ANALYZE.EXP.DECAY, an ASYST word defined specifically for exponential decay acquisition with the Tektronix 7912HB and curve fitting with ASYST analysis tools.*

Further assist for ASYST

Even though the ASYST routines described here are much simpler than an equivalent FORTRAN, BASIC, or PASCAL program (which could run to several hundred or even a thousand or more lines to accomplish the same thing) there's still a lot of detail to attend to in the ASYST routines. It would be nice to simplify application setup even further if possible.

Well, that's possible. Tektronix offers a digitizer driver software package for use with ASYST. This package provides menu-driven access to pulse parameter analysis, waveform differentiation, and fast Fourier transforms. Additionally, the package is linked with specific Tektronix digitizers through instrument-specific drivers. A wide range of Tektronix digitizers are supported, including the 7D20, 7854, 11400 Series, 2430 Series, 7912AD/HB, and the RTD 710.

For example, the 7912AD/HB driver for ASYST supports acquisition of average-to-center waveform data as well as signal-averaged data, edge data, and defects information. A "digitize single sweep" feature allows the software to wait for a single-shot event to occur before acquiring and transferring waveform data. And the included ground-reference routine supports both programmable and manual plug-in amplifiers and time bases.

Not only do you get waveform acquisition at the touch of a function key, you also get a wide range of basic analysis capabilities at the function keys. And the predefined words that provide these capabilities are available for extraction and use in building other routines. There are words to measure level-crossing times, rise and fall times, overshoot, and period. Other words relate to graphics and data presentation for report generation. All of these are in addition to the standard word set provided in the ASYST package.

The Tektronix Digitizer Driver for ASYST gives you the ability to immediately start interactive waveform acquisition and analysis. This in itself is a powerful tool for preliminary or exploratory measurements. At the same time, the many words defined by the driver also provide an extremely rich word resource. These can be used with words already defined by ASYST to create highly specialized application programs, such as the fluorescence decay curve fitting program illustrated here.

Want more information?

To find out more about how Tektronix is making ASYST even easier to use with Tektronix digitizers, contact your local Tektronix Field Office. Or use the **HANDSHAKE** reply card to obtain more information on any of the waveform digitizing and analysis instruments and software described in this article.

7912/ASYST acquisition routines

Following are some selected ASYST words which were used to acquire and process data for the exponential decay curve fitting application. These words can be used as part of other 7912AD/HB applications using ASYST.

For a copy of the complete routine that was used to acquire and display the exponential decay curve fitting example shown in Figure 1, check the appropriate box on the **HANDSHAKE** reply card in this issue.

Set up GPIB linkage

This initial series of words is used to set up the GPIB linkage between the 7912AD/HB and ASYST. These words define device addresses and message termination. Also, the direct memory access (DMA) feature is used for speed during waveform transfers, and a buffer is defined and linked to the system to support DMA transfers. Other activities include making the System Controller the GPIB Controller-in-Charge by pulsing Interface Clear and asserting the Remote Enable Line.

```
\  Set up GPIB communications with 7912AD or 7912HB and
\  programmable plugins (Assumes Primary Address of 3)
\
3  GPIB.DEVICE DIG                      \Digitizer (Tek 7912AD or 7912HB)
0  SECONDARY.ADDRESS
EOI.ON                                  \Terminate on EOI asserted
EOS.OFF                                 \No extra End-of-String character
INTEGER DIM[ 1030 ] ARRAY BIN.DATA      \Waveform data input buffer
BIN.DATA []GPIB.BUFFER                  \Declare it
BIN.DATA DMA.GPIB.BUFFER                \Make it available for DMA

3  GPIB.DEVICE AMP                      \Amplifier (Tek 7A16P or 7A29P)
1    SECONDARY.ADDRESS
3  GPIB.DEVICE TB                       \Timebase (Tek 7B90P)
2    SECONDARY.ADDRESS

SEND.INTERFACE.CLEAR                    \Become Controller-In-Charge
REMOTE.ENABLE.ON
```

Acquire waveform

Here, the word ACQ.ATC is defined. This word commands the 7912AD/HB to digitize data, perform an internal Average-to-Center (ATC) trace operation, and send the ATC waveform to ASYST in the DMA transfer mode. Following transfer, the DMA buffer is unpacked into an integer array and converted from 7912 format (alternating High and Low order bytes) to a uniform integer array. This integer waveform array is 512 points long. The summed edge values range from 0 to 1023, depending upon waveform amplitude. These summed values for each point should be divided by two in the system controller to complete the ATC operation for valid voltage scaling. (ACQ.ATC is defined here for use in later word definitions associated with instrument setup.)

```
\  Digitize and transfer Average to Center waveform and exit
\  with integer waveform data on stack.
\
:  ACQ.ATC
   " DIG DAT;ATC;READ ATC" DIG GPIB.WRITE   \Digitize the data
   ME LISTENER                              \Set up transfer
   DIG TALKER
   DMA.LISTEN                               \Use DMA for speed
   UNLISTEN                                 \Release GPIB
   UNTALK

   BIN.DATA UNPACK                          \Unpack buffer to integers
   DUP
   SUB[ 4 , 512 , 2 ]                       \Select high bytes
   256 *                                    \Shift them
   SWAP
   SUB[ 5 , 512 , 2 ]                       \Select low bytes
   +                                        \Add them to shifted high bytes
;
```

Acquire ground reference

GET.GND.LEVEL automatically acquires a ground reference preceding actual waveform acquisition. It stores the plug-in settings, then sets the vertical plug-in coupling to ground and the time base to auto-trigger using LINE as the Triggering Source. This provides a ground reference trace for capture. Then the previously defined auto-intensity words are used to ensure that a good data trace is available for acquisition. Ground trace acquisition is done with the previously defined ACQ.ATC word, and the resulting waveform array values are averaged to obtain a single ground-reference value, which is stored in GND.LEVEL. The process completes by returning the vertical and time base plug-ins to their original settings.

```
REAL SCALAR GND.LEVEL                       \Mean ground level
100 STRING "AMP.SETS                        \Buffer for amplifier settings
100 STRING "TB.SETS                         \Buffer for timebase settings

:  GET.GND.LEVEL
   " SET?" AMP GPIB.WRITE                   \Store amplifier settings
   "AMP.SETS AMP GPIB.READ
   " SET?" TB GPIB.WRITE                    \Store timebase settings
   "TB.SETS TB GPIB.READ
   " CPL GND" AMP GPIB.WRITE                \Ground the amplifier input
   " MOD PPA;SRC LIN" TB GPIB.WRITE         \Auto trig on line signal

   AUTO.INTENSITY                           \Set intensity for a good trace
   ACQ.ATC                                  \Get a ground trace waveform
   MEAN                                     \Find average
   GND.LEVEL :=                             \Store ground level

   "AMP.SETS AMP GPIB.WRITE                 \Restore amplifier settings
   "TB.SETS TB GPIB.WRITE                   \Restore timebase settings
;
```

Fit curve

This word performs the exponetial curve fit and evaluates the fitted function at the same X values as acquired data. Requires START.INDEX and N as limit indices for curve fit.

```
:  COMPUTE.CURVE
   XX []RAMP                                \Create linear ramp (1 .. N)
   XX SUB[ START.INDEX , N ]                \Select decay portion of ramp
   WFM SUB[ START.INDEX , N ]               \Select decay portion of data
   LEASTSQ.EXP.FIT                          \Perform the curve fit
   COEF :=                                  \Store coefficients of fit
   FITTED []RAMP                            \Compute fitted curve
   FITTED COEF [ 1 ] *                      COEF [ 2 ] +
   EXP FITTED :=                            \Store it
;
```

Auto intensity

Two words are defined to automatically set the 7912AD/HB main writing intensity. These words assume that the trace is positioned fully on-screen. Also, these words require a continuous trigger signal so that a number of waveform captures can be made for intensity optimization.

The auto-intensity process begins with setting a moderately low trace intensity. The low-intensity waveform is digitized and a count is made of the acquired vertical values. Typically the count is zero or very small for low intensity settings. The trace intensity is increased a small amount and the acquisition and vertical value count is repeated until the count falls into the range of 780 to 1000 vertical values. This typically is an optimum vertical value range for waveform description.

Automatic checking could also be included to ensure that intensity does not become too high, such as would be the case if a portion of the waveform were positioned off-screen. This was not done here, however, because of processing speed goals.

```
INTEGER SCALAR NVER                    \Number of verticals found

\  This word digitizes data and reads the byte count of the verticals array
\
:  GET.NUM.VER
     " DIG DAT;READ VER" DIG GPIB.WRITE   \Read verticals array
     ME LISTENER                          \Set up transfer
     DIG TALKER
     STACK.LISTEN DROP                    \Read & discard % header character
     STACK.LISTEN 256 *                   \Shift high byte of byte count
     STACK.LISTEN +                       \Add low byte of byte count
     1 - 2 / NVER :=                      \Store in NVER
     DMA.LISTEN                           \Quickly read & discard verticals
     UNLISTEN                             \Release the GPIB
     UNTALK
;

INTEGER SCALAR MAI                     \Main intensity
INTEGER SCALAR INTENS.START            \Starting value for intensity
INTEGER SCALAR INTENS.INCR             \Increment for intensity increase
INTEGER SCALAR NVER.MIN                \Min number of vert values accepted

250 INTENS.START :=                    \Initialize variables
2 INTENS.INCR :=
1000 NVER.MIN :=

\  This word iteratively determines a good trace intensity and sets digitizer at that level.
\
:  AUTO.INTENSITY
     " MAI 0" DIG GPIB.WRITE            \Turn off trace
     75 MSEC.DELAY                      \Let target erase
     INTENS.START MAI :=                \Get a starting intensity
     BEGIN
       MAI INTENS.INCR + DUP MAI :=     \Increment the intensity
       " MAI" "." "CAT DIG GPIB.WRITE   \Set it in digitizer
       GET.NUM.VER                      \Digitize & count verticals
       NVER NVER.MIN >                  \Enough?
     UNTIL                              \Loop until enough trace intensity
;
```

Set scale factors

The two words defined here are used to acquire scale factors for the waveform data. GET.NUMERIC.PARM requests a numeric parameter, such as intensity or vertical scale, from the 7912AD/HB mainframe. GET.SCALE.FACT uses GET.NUMERIC.PARM to request the vertical and horizontal scale factor information from the 7912AD/HB. These values can be read from the 7912AD/HB mainframe even when non-programmable plug-ins are being used. The acquired factors are scaled to represent voltage per digitizer level and time per digitizer point and are stored in VOLTS.PER.LEVEL and TIME.PER.POINT.

```
40 STRING "TEXT.BUF

\  Word to read and decode a numeric parameter from the digitizer.
\  Enter with command header on string stack, return with numeric
\  result on number stack.
\
:  GET.NUMERIC.PARM
     "DUP                               \Save a copy of the command header
     " ?" "CAT DIG GPIB.WRITE           \Append a '?' and send to digitizer
     "TEXT.BUF DIG GPIB.READ            \Read string result back from dig.
     "TEXT.BUF "SKIP                    \Skip over header part of answer
     ASCII ; "NUMBER                    \Convert numeric string to number
;

REAL SCALAR VOLTS.PER.LEVEL            \Volts per digitizer level
REAL SCALAR TIME.PER.POINT             \Sample interval

:  GET.SCALE.FACT
     " VS1" GET.NUMERIC.PARM            \Read Volts per division
     64 / VOLTS.PER.LEVEL :=            \64 levels per div
     " HS1" GET.NUMERIC.PARM            \Read Time per division
     51.2 / TIME.PER.POINT :=           \51.2 samples per div
;
```

CLASSES AND SEMINARS

Tektronix offers classes and workshops for the convenience of Tektronix customers with application, operational, or service training needs. Here's the schedule of classes and workshops to be offered in the near future.

IG Customer Training Workshops

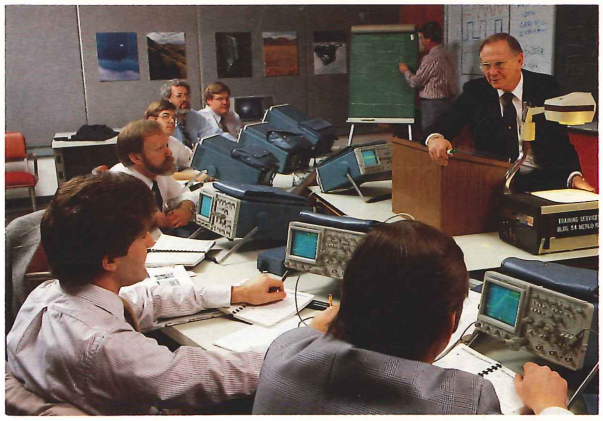
Call Tektronix IG Customer Training, 1-800-835-9433, ext. 430 to register for the following workshops.

CLASS	LOCATION	DATES
Using a 4041 System Controller	Beaverton	Apr 5-7
Using the PC as a Controller	Raleigh	Apr 1
7912AD/7612D Advanced Waveform Processing	Beaverton	Feb 23-26
2230 Digital Storage Measurements	Raleigh	Mar 29
2430A Advanced Digital Measurements	Raleigh St. Louis	Mar 30-31 May 4-5
7854 Waveform Processing	Beaverton	Mar 29-30
11301/11302 Measurement and Analysis	Irvine Chicago	Mar 24 Apr 28
11401/11402 Waveform Measurements	Los Angeles Irvine Chicago	Mar 8 Mar 22 Apr 26
11401/11402 Advanced Waveform Measurements	Los Angeles Irvine Chicago	Mar 8-9 Mar 22-23 Apr 26-27

Most of the above workshops are available in a **self-study** format. **On-site** training is also available. For information call 1-800-835-9433, ext 430.

Workshop and class sizes are limited. We recommend that you enroll early. Other classes are planned beyond this schedule. For more information or to register, call the numbers listed above.

We retain the option to cancel or reschedule classes or workshops.



Service Training Classes

Call Tektronix Service Training, 1-800-835-9433, ext. WR1407 to register for the following classes.

CLASS	LOCATION	DATES
465B/475A Portable Oscilloscope	Boston Atlanta	May 2-6 July 25-29
2215/35/36 Portable Oscilloscope	Wash. DC Atlanta	May 23-27 Aug 1-5
2465A Portable Oscilloscope	Dallas Dallas Atlanta	Mar 21-Apr 1 Apr 11-22 Jun 6-17
7904/7633 Laboratory Storage Oscilloscopes	Boston Irvine	Mar 21-Apr 1 July 11-22
7912HB Programmable Digitizer	Beaverton	Oct 3-14
7854 Waveform Processing Oscilloscope	Beaverton	Oct 24-Nov 11
TM 500 Calibration Package	Boston	Sept 12-23
113XX/114XX Programmable Oscilloscopes	Beaverton Beaverton	Feb 29-Mar 11 Aug 15-26

In addition to classroom instruction, Tektronix Service Training has a variety of training packages and video tapes available for self-study. Classes are also available for maintenance of other Tektronix products. Call for further information.

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