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HANDSHAKE

NEWSLETTER OF SIGNAL PROCESSING AND INSTRUMENT CONTROL

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A look inside

Some of the earliest signal digitizing techniques used cameras. Oscilloscope displays were photographed and digital values were ascribed to the resulting waveforms using drafting techniques — a time-consuming and often error-prone method.

With the advent of the digitizing oscilloscope, the camera lost its prominent place in the digitizing world. These new digitizers were not only faster — almost instantaneous digitizing — but much more accurate. And their higher cost was offset by the time they saved.

Now, the new Digital Camera System from Tektronix returns the camera to an important position in signal digitizing. This new camera provides accurate and easy digitizing with the initial low cost normally associated with cameras. At the same time, its many features and capabilities advance the world of digitizing into areas previously accessible only with the most sophisticated digitizing equipment. For more information on how you can expand your digitizing options, see the article **"New scope camera digitizes waveforms to 12 bits at 1 GHz."** A companion article, **"Where does the resolution come from? Is it magic?,"** discusses how the resolution of the Digital Camera System is determined.

Several new software packages which run on the IBM PC, PC/XT, PC/AT, and compatibles are introduced in this issue. DCS01 Software for the Digital Camera System is described in the above articles. In addition, 10Z210 Signal Processing and Display Software is discussed in the article **"Signal processing tools for your IBM PC"** and S42P301 ASYST Software is featured in the articles **"Get an assist in your signal processing measurements"** and **"Putting ASYST to work ... Engine performance measurements."**

New product introductions are an important part of **HANDSHAKE** and this issue is no exception. New products include the 7250 6 GHz Transient Digitizing Oscilloscope, the 2246 100 MHz Oscilloscope, the 2445A 150 MHz Oscilloscope, the 2465A 300 MHz Oscilloscope, the 370 Programmable Curve Tracer, and the 2430M MATE/CIIL Digital Oscilloscope.

We hope that you find answers to your signal processing problems in this issue of **HANDSHAKE**. For more information on any of the products described in this issue or for help with your signal measurement needs, contact your local Tektronix Sales Engineer or the Tektronix Sales Representative for your country. And be sure to tell them you saw it in **HANDSHAKE**!

A. Dale Aufrecht
HANDSHAKE Editor

New scope camera digitizes waveforms to 12 bits at 1 GHz

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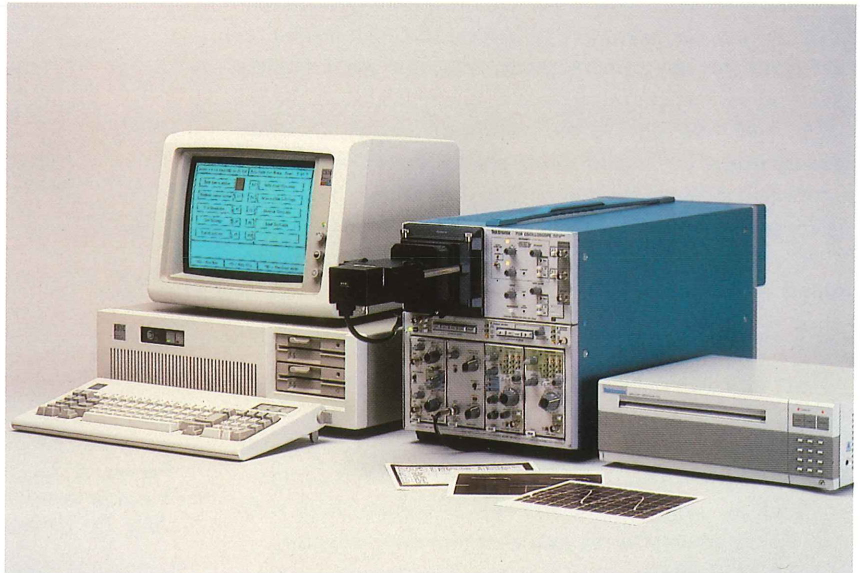


The new Tektronix Digitizing Camera System operates with your standard analog oscilloscope to provide 12-bit waveform digitizing to the full scope bandwidth as well as waveform processing with an IBM PC, PC/XT, PC/AT, or compatible.

There's a completely new way to digitize waveforms. It provides extremely high resolution — to 12 bits (4096 vertical levels) — and it can grab single-shot waveforms up to a 1-GHz bandwidth with 4-picosecond sample resolution — that's an effective sampling rate of 250 gigasamples per second. Figure 1 shows a 1.111-GHz waveform captured and digitized by the Digitizing Camera System (DCS) from a single-shot display on a Tektronix 7104 Oscilloscope. Not only does the Digitizing Camera System keep pace with the world's fastest oscilloscope, but it also provides extensive waveform measurement parameters — all automatically.

Not only is this high-performance digitizing method from Tektronix, the world leader in waveform digitizing, but it also provides accurate digitizing at a low cost. It's low cost, because the waveform is captured with a scan-conversion video camera using proven CCD technology. It's also low cost because the camera fits on most standard analog oscilloscopes, just like the one you already have on your bench. So you probably already have a major part of the system available — an oscilloscope. Even if you buy a new scope to go with the Digitizing Camera, system cost is still less than a comparable bandwidth digital storage oscilloscope or transient digitizer.

You may already have another key part of the system too. That's an IBM PC, PC/XT, PC/AT, or compatible. So money is saved again. Plus, time is saved. You use your analog scope in the same familiar manner with the C1001 Video Camera attached. The DCS01 Software for the Digitizing Camera System runs on the PC, giving you menu prompts for quick and easy system setup by simply pressing PC function keys.

The following minimum system configuration is required to run DCS01 Software:

Required hardware:

- IBM PC, PC/XT, PC/AT or compatible (PC/AT recommended).
- 384 Kbytes memory (512 Kbytes recommended).
- One double-sided, double-density disk drive (hard disk also recommended).
- 8087 or 80287 math co-processor.
- Color graphics board.
- Compatible graphics monitor.

Required software:

- MS-DOS, version 2.1 or higher (version 3.1 recommended).

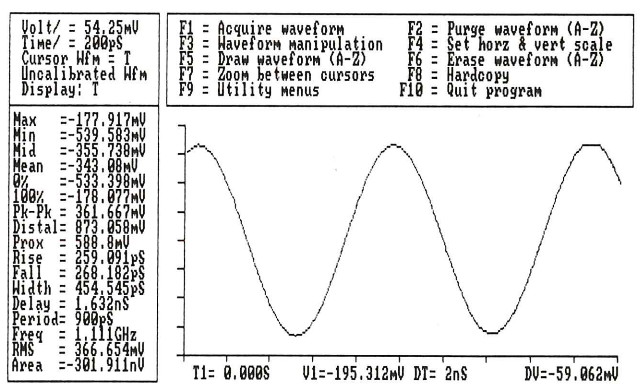


Figure 1. *A 1.111-GHz waveform captured and digitized by the Digitizing Camera System from a single-shot display on a Tektronix 7104 Oscilloscope. Notice the measurement information provided on the display.*

Optional hardware:
- GPIB board (Tektronix GURU board; National Instruments GPIB-PC, PC-2, or PC-2A; or IBM).

What's more, the software includes extensive waveform conditioning routines to extract high-accuracy, high-resolution data from the raw camera pixels. You also get complete waveform parameter measurements, automatically, on the PC screen, and you can use the waveform cursors for other measurements. For documenting results, the PC screen can be copied to a dot-matrix printer. There are also two new video copiers to make direct copies of video frames or copies of the PC screen (see sidebar **New video copiers capture camera output**).

Easy installation

The major components of the Digitizing Camera System are shown in Figure 2. They consist of the C1001 Video Camera, a Frame Store Board, appropriate cables, and the DCS01 Software. The Digitizing Camera System is compatible with most Tektronix oscilloscopes as well as scopes from other manufacturers using available mounting adaptors.

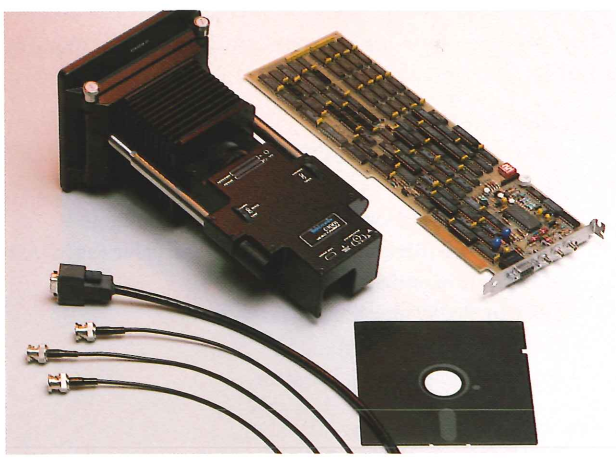


Figure 2. Major components of the Digitizing Camera System. The software is compatible with MS-DOS or PC-DOS running on IBM PCs and compatibles.

The general system configuration of these components is shown in block diagram form by Figure 3. The C1001 Video Camera mounts on the CRT bezel of the oscilloscope. The Frame Store Board mounts in the expansion board slots of an IBM PC or compatible.

Figure 4 provides additional functional detail of the Frame Store Board. Following is a brief overview of its operation: The video signal from the camera (or other video source) is connected to the Video Sync Separator. The Video A/D Converter converts the video signal to an 8-bit digital output and stores it in the Video Memory. The video data passes through the Lookup Table Memory which contains data to perform level shifting, threshold recognition, division by a constant,

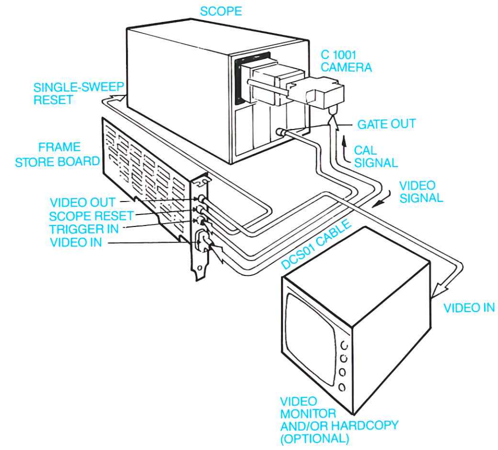


Figure 3. General hookup of system components (video monitor is optional). The Frame Store Board installs in an IBM PC or compatible.

and other signal processing on the video signal. The incoming video data can be summed with video information already stored in the Video Memory. This real-time summing of video insures that the waveform on the CRT is captured in total by the camera, regardless of the scope's trigger timing. The digitized video output is then converted back to a video signal by the Video D/A Converter to drive a video monitor, video copier, VCR, etc.

The Calibration Generator produces the "calout" signal which can be used with the calibration software to produce a closed-loop system to qualify distortion errors in the system and provide correction for subsequently acquired data. The remaining blocks provide timing, triggering, and interfacing for the system.

System setup

After installing the Frame Store Board in your PC, attaching the C1001 Video Camera to the scope, and loading DCS01 Software, the remaining installation and configuration takes only another 5 to 10 minutes. When accuracies of 1% or better are required, this can include running calibration routines to characterize the camera-lens system and the scope CRT for later software correction.

The setup calibration process is straightforward and uses menu prompts and PC function key selections. Operation for capturing and manipulating waveform data requires pressing only a few more function keys. The menu for general operation is always displayed on the PC screen, above the active waveform, and the results of waveform calculations are displayed to the left (see Figure 1). More details on menu selec-

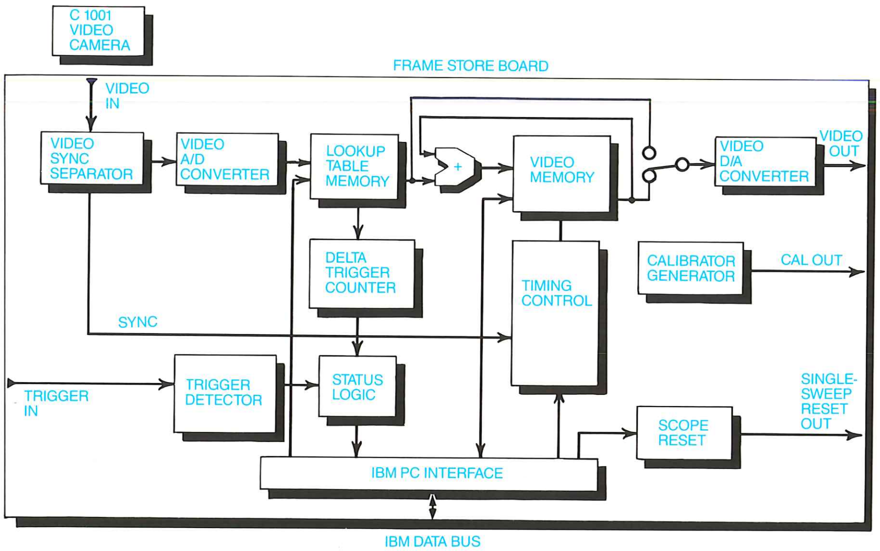


Figure 4. Functional operating diagram of the Digitizing Camera System showing detail of the Frame Store Board.

tion are given in the accompanying sidebar entitled **System menus.**

Camera sees the waveform, board digitizes it

From a general operating point of view, the key thing to note is that the camera sees the waveform on the scope screen. The light from the scope's screen phosphor is optically coupled to the camera, which captures it on a 490-vertical x 384-horizontal element photosensitive CCD scan-conversion target. This 490 x 384 pixel image is then transferred out of the camera at a video rate in the NTSC RS-170 Standard video format for conversion by the Frame Store Board. Because the waveform image is optically coupled into the CCD scan converter — essentially parallel optical sampling — the major bandwidth limit is the scope itself.

When the scope is in repetitive sweep mode, trace phosphor remains bright and the Digitizing Camera System is able to provide waveform capture to the full analog bandwidth of the scope. On single-sweep waveforms, however, conventional CRT scopes are writing-rate limited by trace brightness. The trace intensity begins to drop out on fast slew rates.

Single-shot bandwidth for conventional CRTs can be up to two-thirds of the analog bandwidth. But digitizing to the full bandwidth of the scope on single-shot waveforms is possible with scopes having micro-channel plate (MCP) CRTs. This is because the MCP provides electron-beam multiplication for substantial trace brightening (high visual writing rate) on single-shot waveforms. As a result, the Digitizing Camera System can capture single-shot transients to the full bandwidth of Tektronix MCP scopes — 350 MHz with the 2467 Oscilloscope and 1 GHz with the 7104 or R7103 Oscilloscope.

The 7104 is the world's fastest real-time analog scope and is, at present, the limiting factor on the DCS high-end bandwidth.

The nominal resolution of the Digitizing Camera System is specified as 12-bits. This is a derived specification — see the accompanying article **Where does the resolution come from? Is it magic?** for information on how this resolution is determined.

Averaging, save-on-delta, and waveform parameters too

Waveforms are initially stored by the Frame Store Board and then transferred to the PC. In the PC the waveform data is processed, and stored in RAM memory under a single letter designator (A-Z). From here, waveforms can be manipulated further by menu selections, computed waveforms can be created (e.g., X = A*B), and waveforms can be copied to disk files for permanent storage. These are just general operation categories, with each category having numerous menu options or variations.

Other key waveform capture features include averaging and save-on-delta. Averaging computes an average waveform composed of a specified number of individual waveform captures. A common application of this is reduction of noise on low-level signals. Another useful application is creation of an average waveform from an experiment where the characteristic response waveforms may exhibit minor variations from the norm. This is often the case in stimulus/response studies in biophysical experiments where minor experimental variations need to be averaged out.

The save-on-delta feature allows you to specify an upper and lower bounds limit for the waveform. These limits are saved in memory and used for comparison against acquired waveforms. If any of the acquired waveforms violate the limit bounds, the violating waveform is automatically saved. This feature is quite useful for quality control checks, fault monitoring, and general capture of aberrant or out-of-limits waveforms in applications ranging from circuit evaluation to muscle response studies. Also, it can be used for video triggering on single-shot events — a sort of "save-on-light" mode.

In all cases, displays of captured waveforms are accompanied by any pre-selected measurement parameters shown to the left of the waveform (see Figure 1). Displayed waveforms are also accompanied by a pair of measurement cursors which can be moved about on the waveform for making time and voltage difference measurements. The results of these cursor measurements appear under the waveform display and are continuously updated as the cursors are moved on the waveform.

The cursors can also be used to mark off a segment of the displayed waveform for the Zoom feature. The Zoom feature expands the marked segment to full display size and is useful for close examination of high-resolution features.

A choice of system configurations

Depending upon your needs, the Digitizing Camera System can be configured in a variety of ways. Some of the possible configurations are illustrated in Figures 5 through 8. Figure 5 is the most typical use as a digitizing camera. Figure 6 shows extension of this basic system to a GPIB configuration (GPIB board optional; contact your local Tektronix Field Office or representative for availability). With an appropriate system configuration, the system controller can change system parameters based upon data that the C1001 Video Camera captures from the screen. For example, with a Tektronix CG 5001 Programmable Oscilloscope Calibration Generator included in the system, the system can be set up for auto-calibration before each measurement is made. Many other applications using the C1001 Video Camera as the "eyes" for the system are possible.

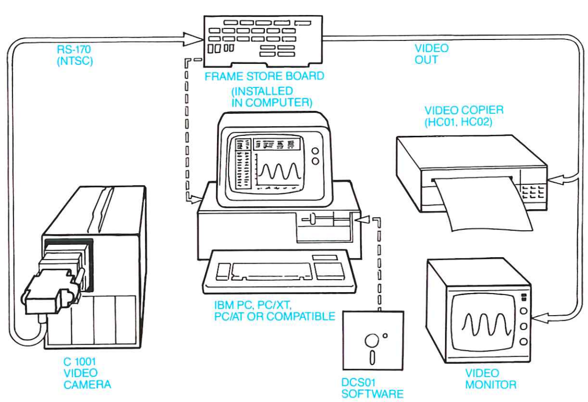


Figure 5. *The standard DCS configuration for digitizing waveforms from an analog oscilloscope.*

Figure 7 shows a simple configuration for just recording waveforms to other media. This system does not require an IBM PC or Frame Store Board, but does require use of a power supply and video interface unit (optional accessory; contact your local Tektronix Field Office or representative for availability). Video from the C1001 Video Camera is coupled directly to either a video copier or a video tape recorder. The C1001 Video Camera keeps pushing out video frames, just

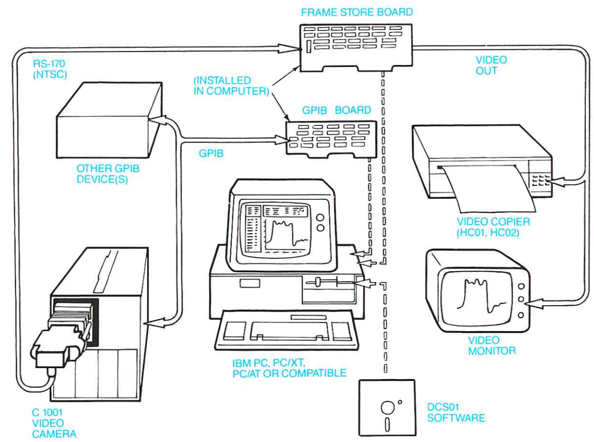


Figure 6. *An extension of Figure 5 adds GPIB system control capability, with the C1001 Video Camera putting "eyes" on the scope for automatic system feedback.*

like any other video camera, and two to six hours worth of frames can be recorded to tape with a conventional VCR.

One application of the configuration in Figure 7 is unattended monitoring of an infrequent event. Of course, once the event has been recorded on video tape, it would be nice to be able to analyze the event with DCS Software. To do this, the system can be reconfigured as shown in Figure 8, with the video tape recorder acting as the input device to the Frame Store Board. The video tape is then scanned until the event of interest is found and captured by the Frame Store Board. From this point on, system operation is the same as for a signal captured from the CRT.

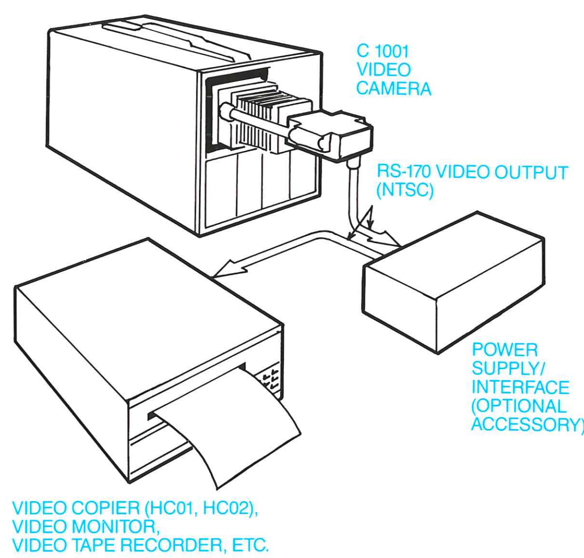


Figure 7. *Configuration for copying video frames to either a video copier or a video tape recorder.*

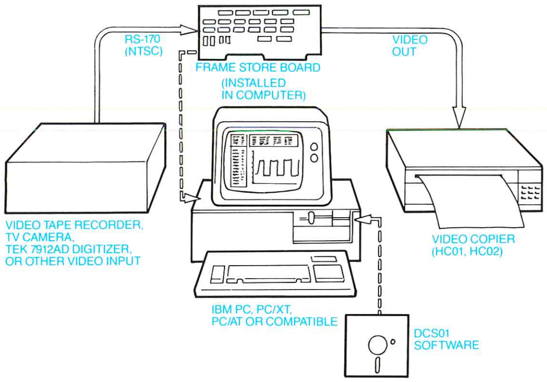


Figure 8. *Feeding video frames into the system for digitizing and comparison.*

Other applications abound for the configuration in Figure 8. In fact the Digital Camera System, much like any other camera system, is free to be used to the limits of your imagination.

Which brings up still another point. The C1001 Video Camera can also be detached from your scope and used to take a picture of your test or experiment setup (see Figure 9), basically just like you would use any other camera. The difference is that the picture is stored in digital form or printed out on a video copier instead of being exposed on film.

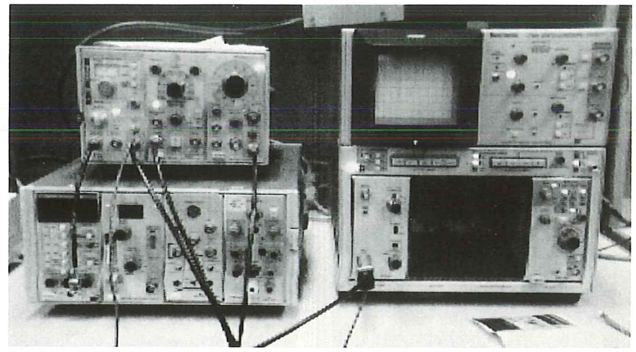


Figure 9. *The Digitizing Camera System can take photos to document test system or experiment setups as shown by this video hard copy.*

Sound interesting?

The DCS01 Digitizing Camera System — just imagine what you can do with this new camera. Then call your local Tektronix Field Office or representative for further information on system configurations and application details. Or for a data sheet and brochure, check the appropriate box on the **HANDSHAKE** reply card.

A video tape and a demonstration disk showing the Digitizing Camera System in operation are available. Contact your local Tektronix Field Office or representative for details.

Video copiers capture camera output

Two new video copiers are part of the Digitizing Camera System. They provide high-speed, high-resolution, black and white prints of waveforms or computer graphics displayed on instrument CRTs, TV screens, or personal computer monitors. Based on thermal print technology, the copiers document measurement data for as little as six cents per print (4 by 5 print) compared to seventy-five cents per print with traditional film methods.

The HC01 Video Copier produces a 4 by 5 inch print (105 by 110 millimeter) in 17 seconds (single copy speed). The HC02 produces an 8 by 10 inch print (216 by 279 millimeter) in 21 seconds. Copying speed can be improved by loading one image while another is printing.

Capable of 16 levels of gray-scale, the copiers accurately reproduce halftones with a resolution of up to 640 dots by 512 lines. Intermediate levels between the prescribed 16 can be achieved via electronic dithering techniques.

Video images are stored in internal RAM memory prior to output to thermal paper. Input can come from a variety of sources: Composite video with switch selection of the NTSC, PAL, or SECAM standard; RGB TTL for communication with IBM PCs or compatibles or teletext/videotext machines; and an 8-bit parallel port with built-in ASCII character set and bit-graphics for interface with computers.

Beyond use with the Digitizing Camera System, the HC01 and HC02 Video Copiers can be used for medical imaging, security documentation, making copies from video tape machines, printing images from a live camera, or other uses.

For additional information on the HC01 and HC02 Video Copiers contact your local Tektronix Field Office or the sales representative for your country. Data on these video copiers will be included with information on the Digitizing Camera System; check the appropriate box on the reply card included in this issue of **HANDSHAKE.**

System menus

The DCS01 menu system provides easy access to a wide range of storage, processing, and file maintenance functions. The main menu functions are shown in Figure A and discussed briefly below. Figure B provides a more detailed view of the menu structure.

Main menu

Acquire Waveform acquires a waveform according to the Acquisition settings and stores the waveform data under a single letter designation in PC RAM.

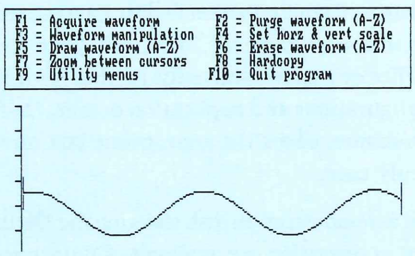


Figure A. *Main menu bar for DCS01 Software.*

Purge Waveform deletes the specified waveform from PC RAM (does not affect disk-stored waveforms or PC display).

Waveform Manipulation calls up a submenu allowing various waveform manipulations — ADD, SUBTRACT, INTEGRATE, etc. (See Figure B for complete list.)

Set Horiz & Vert Scales allows entry of Volts/Div and Time/Div scaling to match the oscilloscope settings.

Draw Waveform draws a RAM-stored waveform on the PC monitor screen.

Erase Waveform erases waveforms from the display (does not affect RAM-stored or disk-stored waveforms).

Zoom Between Cursors expands the displayed waveform segment marked off by the cursors.

Make Hardcopy causes the PC screen to be printed on an Epson compatible dot-matrix printer connected to the PC's printer port. The screen display can also be copied to an optional video copier connected to Video Out.

Utility Menus calls up a new menu level for setup procedures — including selection of automatically computed and displayed waveform parameters — and various file manipulations. (See Figure B for detailed listing.)

Quit Program allows exiting to DOS through three different selections: 1) **Temporary Exit** which exits to DOS but maintains all DCS01 program parameters and a return path to DCS01; 2) **Save All And Exit** which saves all program information to disk and exits to DOS; and 3) **Exit Without Save** which simply exits to DOS without saving any program data.

DCS01 MENU TREE

- MAIN MENU
  - Acquire Waveform
  - Purge Waveform (A-Z, All)
  - Waveform Manipulation
    - ADD Waveforms
    - SUBTRACT Waveforms
    - MULTIPLY Waveforms
    - DIVIDE Waveforms
    - INTEGRATE Waveforms
    - DIFFERENTIATE Waveforms
    - SCALE Waveforms
    - SMOOTH Waveforms
    - OFFSET Waveforms
  - Set Horz & Vert Scales
  - Draw Waveform (A-Z)
  - Erase Waveform (A-Z, All)
  - Zoom Between Cursors
  - Hardcopy
  - Utility Menus
    - System Focus (4 Bar-Graph Display)
    - Calibrate Camera System
    - Acquisition Settings
      - Single Sweep ON/OFF
      - Save On Delta ON/OFF
      - Average ON/OFF
      - Calibrate Waveform ON/OFF
      - Video Data ON/OFF
      - Set Delta Mask
      - Auto-Log ON/OFF
    - Waveform Parameters
      - Maximum ON/OFF
      - Minimum ON/OFF
      - Middle ON/OFF
      - Mean ON/OFF
      - 0% ON/OFF
      - 100% ON/OFF
      - Peak-to-Peak ON/OFF
      - Distal ON/OFF
      - Proximal ON/OFF
      - Risetime ON/OFF
      - Falltime ON/OFF
      - Pulse Width ON/OFF
      - Delay ON/OFF
      - Period ON/OFF
      - Frequency ON/OFF
      - RMS ON/OFF
      - Area ON/OFF
    - File Operations
      - Directory (Windowed)
      - Delete File
      - Copy Waveform to File
      - Copy File to Waveform
      - Copy File to File
      - Copy Delta Mask to File
      - Copy File to Delta Mask
      - Copy Waveform to Waveform
      - Convert Waveform to ASCII
    - Global Settings
      - Save Settings
      - Load Settings
      - Default Drive & Sub-Dir
      - Default File Extension
      - Sort Directory NAME/TIME
      - Inverse
      - Color
    - Display Settings (Full-Page Display)
    - Magnification Ratio
  - Quit Program
    - Temporary Exit
    - Save All And Exit
    - Exit Without Save

Figure B. *Menu tree for DCS01 Software.*

Where does the resolution come from? Is it magic?

Geoff Rhoads
DCS Optical Engineer
Accessories Division Engineering
Tektronix, Inc.

The Digitizing Camera System has a specified vertical resolution of up to 12 bits and accuracy better than the inherent accuracy of the oscilloscope it is used with (see preceding article **New scope camera digitizes waveforms to 12 bits at 1 GHz).** If you're familiar with signal processing and quick with your calculator, this may raise some questions in your mind about how 12-bit vertical digitizing can be achieved. How do you get 4096 discrete levels out of 490 photosensitive elements? Where does the additional information come from?

Derived resolution

The truth of the matter is that the trace's Z-axis (brightness) contains considerable additional information in each pixel (see Figure 1). With the digitizing camera, this brightness information is represented by 8-bit gray-scale resolution (256 shades of gray). Combined with the known photometric properties of oscilloscope traces, this brightness information provides sufficient information for software derivation of the trace center with 12-bit resolution.

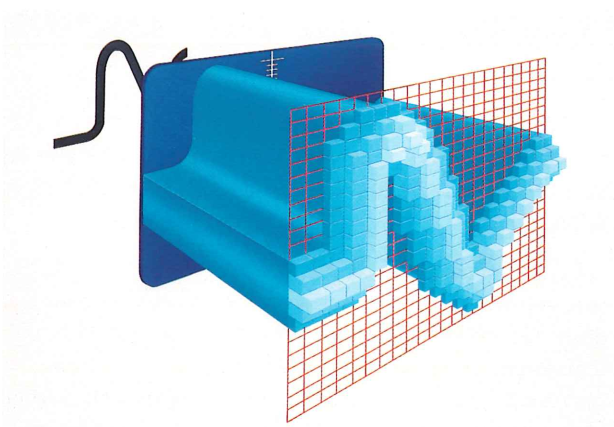


Figure 1. Simplified view of a trace on a phosphor screen. Blocks indicate individual "pixels" of information. Shading and height of blocks indicate intensity (white being brightest).

Actual analytic verification of 12-bit resolution is a rather lengthy and involved process — too lengthy to cover here. However, the basic idea is that the trace width (or beam diameter) covers several pixels, and the trace intensity on an axis orthogonal to the trace axis (i.e., the beam intensity profile) is ideally a Gaussian distribution (see Figure 2).

In a noiseless system, simple center-finding algorithms allow statistical prediction of the trace center with an extremely high

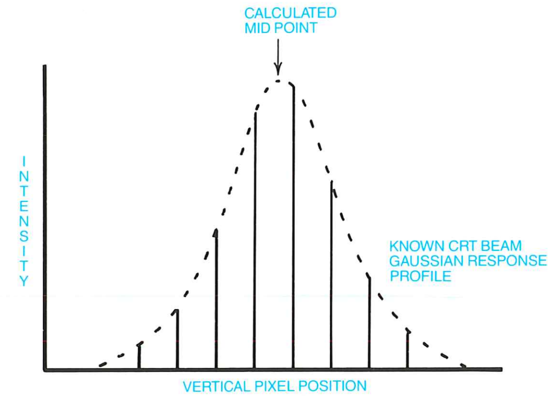


***Figure 2.** Digitally sampled intensity profile of a typical oscilloscope trace. This also represents the intensity profile of a spot on the CRT.*

degree of resolution — 15 bits or more. However, given the optical and electrical readout noise of a typical oscilloscope/camera combination, a conservative specification of the empirically derived digitizing is 12-bits of resolution or better. With micro-channel plate CRT oscilloscopes, empirical resolution has been found right at the 12-bit level. These numbers are found by logging baseline RMS noise and comparing this to the digital noise of a perfect digitizer. This is in slight contrast to traditional digitizer specifications which usually quote fixed A/D parameters (6-bit, 8-bit, 10-bit, etc.) rather than noise properties. Since the DCS resolution has a convoluted relationship to its hardware design, an empirical specification was chosen as the appropriate figure of merit.

In single-shot work, 12-bit resolution often results in finding the trace center well beyond the noise floor of the vertical amplifier. This is analogous to designing a digitizer with a digital bin size much smaller than the analog noise of the instrument. (Bin size refers to the smallest detail observable in a digitizer — the fundamental resolution unit.) The utility of the 12-bit resolution shows itself most prominently when digitizing repetitive signals where the scope acts as an optical averager, as well as in ensuring high-precision digitization of the analog noise floor in single-shot work.

A concern for accuracy

The other factor of concern is accuracy. This is actually made up of several factors — the accuracy of the oscilloscope's signal input channels, the scope's CRT nonlinearities, and the camera lens nonlinearities.

Precision optics. Beginning with the C1001 Video Camera Head, high optic transfer accuracy is maintained by using a special seven-element lens system with four different types of glass used in the lenses. The result is a close range, flat field, high-resolution lens system with only 0.3% geometric distortion at f1.3.

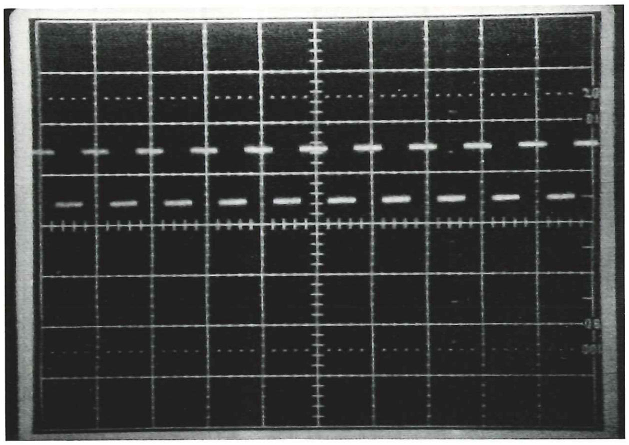


Figure 3. *Calibration square wave used to map out geometric characteristics of the Digital Camera System. In actual operation, the graticule is turned off during system calibration.*

Software calibration. Additionally, the DCS01 Software contains calibration routines that allow further data correction for any remaining geometric distortions of the scope's CRT and the C1001 lens system. This involves generation of many known accurate signals (see Figure 3) which are imaged by the camera, processed to create error-correction factors, and stored. This correction factor is then applied to subsequent waveforms to compensate for geometric errors in the imaging system.

In general, a scope's overall accuracy specification includes both input channel accuracy as well as CRT geometric effects. So, by minimizing both camera lens and CRT effects, the DCS01 System provides overall accuracy that exceeds the basic accuracy of the oscilloscope being used. Not only do you get waveform digitizing and automatic parameter measurements, but you also get accuracy enhancement beyond your scope's basic performance. This is a welcome change to the usual situation where errors become additive as components are added into a system.

Want proof?

Sound too good to be true? Do you want proof that the stated specifications are real rather than magic? The best proof is to see the Digital Camera System in operation on your signals, with your instruments. Call your local Tektronix Field Office or representative for a demonstration of the Digital Camera System today.

MATE/CIIL Interface available on the 2430M

If you're designing an automatic test system that must conform to the U.S. Air Force Modular Automatic Test Equipment (MATE) standard, take a look at the Tektronix 2430M Digital Oscilloscope. This instrument, which is based on the 2430 Digital Oscilloscope (see **New digital scopes pack acquisition power for portable systems**, Fall/Winter 1985 **HANDSHAKE**), incorporates CIIL capabilities. CIIL (Control Intermediate Interface Language) is the universal interface standard for communications between test instruments in U.S. Air Force ATE systems using ATLAS test software.

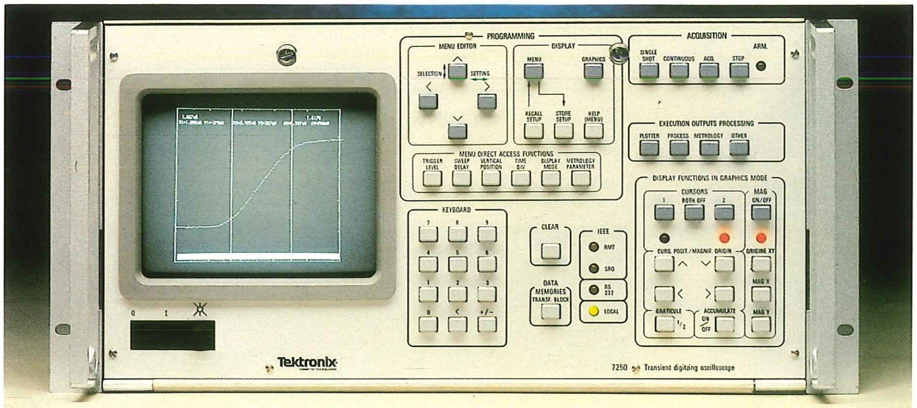
CIIL capability has been imbedded in the 2430M via a special processor board that is directly connected to the standard IEEE-488 connector. The CIIL interface remains transparent to the user except when sending and receiving CIIL commands. Thus the 2430M retains IEEE-488 compatibility while extending interface capabilities to MATE systems.

For more information

To find out more about the 2430M Digital Oscilloscope, please contact your local Tektronix Field Office or the Tektronix sales representative for your country. For a data sheet describing the 2430M, use the **HANDSHAKE** reply card in this issue.

Orders for the 2430M can also be placed through the Tektronix National Marketing Center. Call 1-800-426-2200 toll-free (in Oregon call 627-9000 collect) and tell them you saw it in **HANDSHAKE.**

Advancing digitizer measurements to 6 GHz



Integral display

A built-in monitor provides a bright, clear waveform display. This sharp display allows easy measurements directly from the raw data output of the scan-converter or from the results of internal signal processing. The monitor also displays the menus used to set up and operate the instrument. A readout system displays both instrument settings and the results of signal-processing calculations.

The new Tektronix 7250 Transient Digitizing Oscilloscope advances the state of the art in signal acquisition and digitizing to 6 GHz. Usually, such advanced measurements are associated with hard to use instruments and difficult to view displays. But not so with the 7250! Through the use of on-screen menus and an integral monitor, this instrument is easy to set up and use.

The heart of the 7250 is an advanced scan-converter tube. Output from the scan converter can be displayed on the integral monitor. It is also available as a digital signal to a system controller or as a video output at a rear-panel connector.

Outstanding performance

Outstanding performance is what you need when making high-speed measurements, and this is where the 7250 shines. Bandwidth is DC to 6 GHz (-3 dB) with a risetime of 50 picoseconds. Vertical resolution is 11 bits (2048 points) with 9 bits horizontal (512 points). Trigger jitter is 100 picoseconds or less up to the full bandwidth. Along with excellent signal input characteristics, the 7250 provides an effective means to capture and digitize transient or low-repetition rate waveforms even at the highest frequencies. Figure 1 shows a typical display of a fast-rise signal acquired in the single-shot mode.

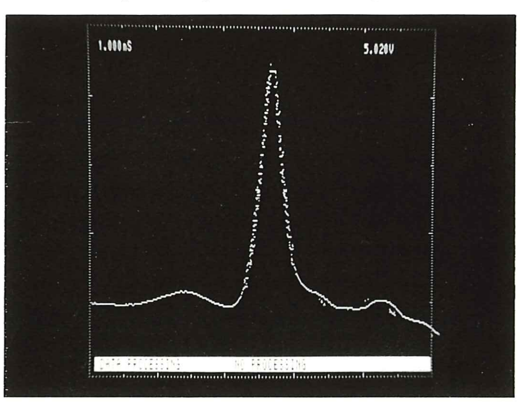


Figure 1. Typical display of a fast-rise signal acquired in the single-shot mode. Risetime of displayed signal is about 50 picoseconds.

A split-screen display mode lets you compare a newly acquired waveform with a stored waveform. Or, two acquired waveforms can be displayed and compared. Figure 2 shows a typical display using the split-screen feature.

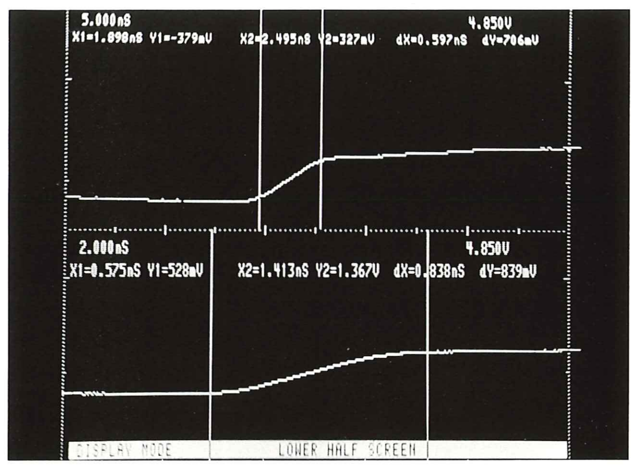


Figure 2. The split-screen feature allows an acquired signal (top) to be compared with a reference waveform (bottom) recalled from local memory.

Built-in processing

To reduce the time required to acquire and process signals, the 7250 provides a choice of acquisition modes. You can select single-shot, continuous, multicurve, averaging, envelope, defects correction, or electronic zero, as well as a choice of filtering and smoothing. Most of these perform in a conventional manner and need no explanation. However, two unique features provided are multicurve and electronic zero. Multicurve provides fast acquisition of signals with storage directly to memory. Electronic zero allows acquisition of a zero level for reference.

On-board waveform processing capabilities to determine signal parameters further enhances signal acquisition and processing. Functions included are: Min/max, peak-to-peak, average value, rms value, risetime, falltime, pulse width, delay time, delta time, frequency, and period. The parameters can be displayed on the integral monitor or sent to a system controller.

Fully programmable

In a measurement system, all functions of the 7250 can be controlled over the IEEE-488 (GPIB) bus. An optional RS-232C interface is also available. In addition to instrument control, acquired signals or the results of waveform calculations can be transferred to the system controller.

Or use it stand-alone

On-screen menus provide quick and easy set up in a stand-alone mode (see Figure 3). Four front-panel setups can be stored in non-volatile memory for later recall. In addition, up to 15 waveforms (31 with additional memory option) and accompanying readout can be stored in local memory. A battery provides memory backup for up to five years.

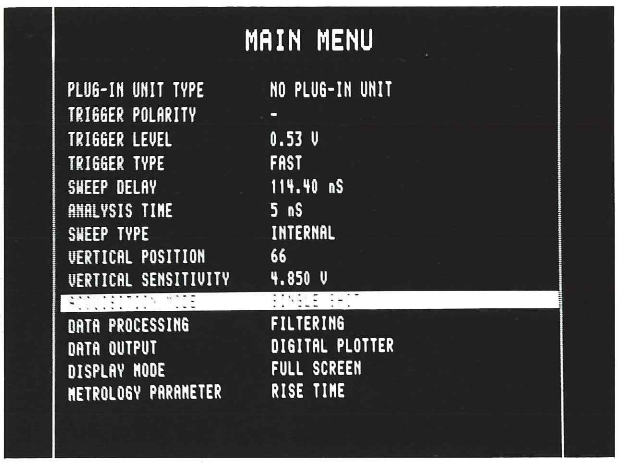


Figure 3. *On-screen menu display allows easy instrument set up.*

Many signal-processing measurements can be made on the acquired signals using the built-in waveform-processing capabilities. Results are displayed on the integral monitor using the readout system. Cursors can be positioned to points-of-interest on the display and measurements made relative to the cursors. An electronic graticule can also be displayed to assist in visual measurements. Figure 4 shows a typical display when used for stand-alone measurements.

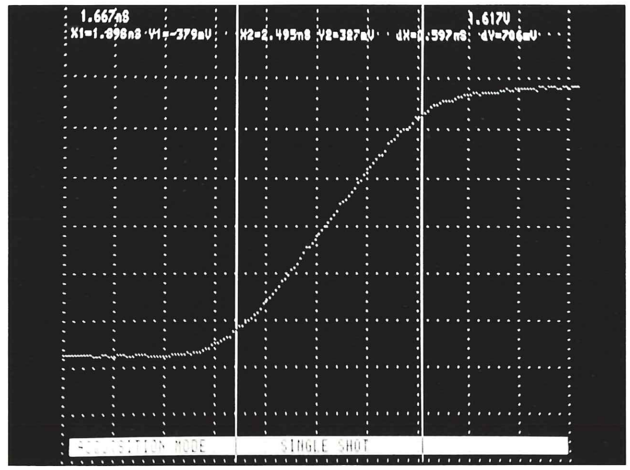


Figure 4. *Cursors can be positioned to points-of-interest on the displayed waveform.*

For more information

This is only a brief overview of the 7250 Transient Digitizing Oscilloscope. For more information, please contact your local Tektronix Field Office or the sales representative for your country. For a data sheet describing the 7250, use the **HANDSHAKE** reply card included in this issue.

Low-cost solutions for ATE

To most people, the term automatic test equipment (ATE) is synonymous with high cost. However, newer test equipment based on the GPIB interface and user-friendly programs which run on the IBM PC are changing that for low- to medium-volume ATE applications.

The article "Tektronix real-time scopes, with parametric measurements, go after low/medium volume ATE markets," **Electronic Component News**, July 1985, by Milan Moncilovich and Bill Law describes how the Tektronix 2465 Special Edition Oscilloscopes along with test system software available from Tekronix can provide flexible yet affordable ATE systems.

For a reprint of this article, check the appropriate box on the reply card in this issue of **HANDSHAKE.**

Analog scopes move into measurement automation

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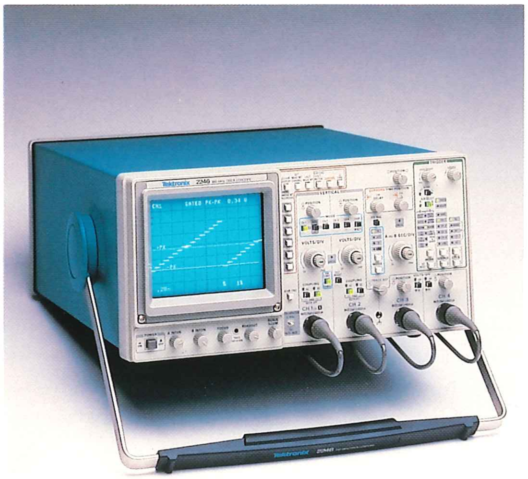

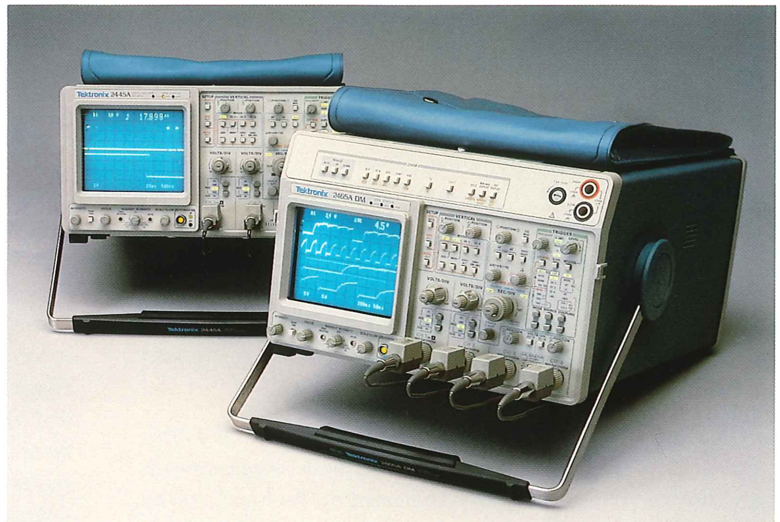

New analog oscilloscopes from Tektronix feature a variety of automation benefits such as push-button measurements and automatic setup. 2246 100 MHz Oscilloscope shown on left, 2445 150 MHz Oscilloscope and 2465 150 MHz Oscilloscope shown on right.

Measurement automation doesn't have to be complicated. Nor does it have to be expensive, or limited to only those special measurement cases that can "justify" it.

Several portable oscilloscopes recently introduced by Tektronix prove these points. First, they offer the simple familiarity of conventional analog scope operation. To this they add push-button automation features that simplify a wide range of day-to-day measurements as well as provide smooth entry into computer-aided measurement applications. And they do this without increased prices — you get automated measurement capability at conventional scope prices.

These new scopes are the 100-MHz 2246 General Purpose Scope (GPS) and the 150-MHz 2445A and 350-MHz 2465A Oscilloscopes. They all offer standard high-performance oscilloscope features, plus automation. The 2445A and 2465A scopes also feature full bandwidth to the probe tip at full 2-millivolts/division sensitivity. Many other oscilloscopes, by contrast, only support their specified bandwidth over a limited range of sensitivities.

Push-button measurements

The 2246 GPS is an example of the new stand-alone automation in analog scopes. It's a four-channel, 2-nanosecond/division sweep speed scope that is ideal for any application requiring 100-MHz bandwidth capabilities. And, when you get ready to make a measurement, you won't have to go through the usual division counting and scale factor multiplications.

Instead, a simple push of a button brings a measurement menu up on screen (see Figure 1). You have immediate push-button access to peak-to-peak, +peak, −peak, DC average, and gated measurements. Push the peak-to-peak button, for example, and the peak-to-peak value of the displayed

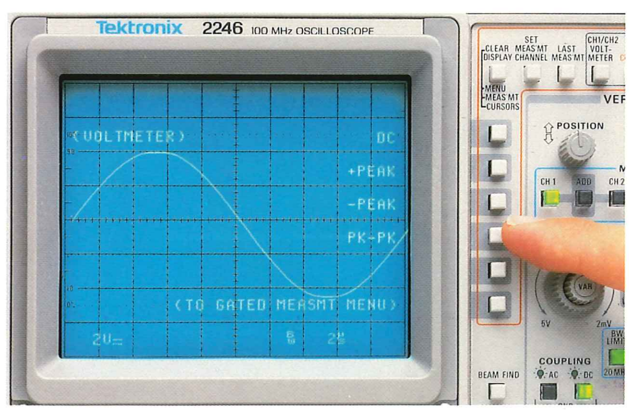

Figure 1. *The new 2246 General Purpose Scope (GPS) is an analog scope with automatic measurement capability. Simply make a menu selection, and the measured value of the displayed waveform appears on screen.*

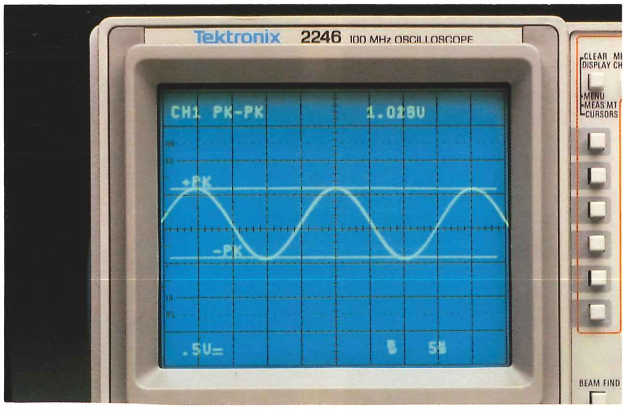

Figure 2. *When a push-button measurement is made, such as the DC average measurement shown here, the GPS screen cursors automatically position themselves on the waveform to show you exactly what is being measured.*

waveform appears in the readout. Additionally, smart screen cursors are automatically positioned on the waveform peaks so you can see exactly what's included in the measurement (see Figure 2).

Push-button measurements can also be made in the GPS's special gated measurement mode. In this mode, measurements are confined to a gated region, indicated on the waveform by an intensified zone as shown in Figure 3. This intensified zone can be expanded or contracted and positioned on the waveform to indicate just the area to be measured. Additionally, since the measurement is made with a real-time analog scope, waveform variations immediately show up in the measurement readout. This is particularly useful in applications where immediate feedback is required such as tuning a circuit to a specific level.

The screen cursors are also automatically positioned to the positive or negative peaks in the gated mode as a measurement aid. These same cursors can also be manually positioned anywhere on the waveform for other voltage or time difference measurements. Cursor measurements can be referenced to ground, for absolute measurements, or referenced to the trigger for precise setting of trigger levels.

Figure 3. *The GPS gated feature allows push-button measurements to be confined to the specific part of a waveform indicated by an intensified zone.*

The new 2445A and 2465A scopes also provide cursor measurements. Cursor measurement capability is relatively new to analog oscilloscopes. However, the power of screen cursors, which can be placed anywhere on-screen, will make this capability an expected feature on future analog scopes.

Automatic setup saves time

There are still other time saving features in these latest analog scope models. Automatic setup is one that will see frequent use. Just press AUTO on the 2445A or 2465A and these scopes set themselves up for standard waveform displays. Even an inexperienced scope user can set up multiple channel displays in a matter of seconds.

When AUTO is pressed, the 2445A and 2465A scopes sense the signals at the probe tips for the selected display channels. Sensed amplitudes and frequencies are used to compute and automatically select front-panel settings and triggering for signal displays. Low duty cycle pulses are even distinguished and set up according to pulse width for best display of pulse detail. And, if more than one channel is selected for display, positioning is automatically taken care of for appropriate trace separation on screen.

Use of AUTO significantly speeds troubleshooting and checks between circuit points where different setups are frequently required. Just move the probe and press AUTO. The scope automatically adjusts its setup for new signal level and sweep speed requirements. Complete setup changes from test point to test point require just one press of AUTO.

While AUTO is intended for setup of conventional signal displays, it is also a time saver for specialized displays or measurement requirements, such as delayed sweep setups. Just press AUTO to get the preliminary setup. Then use the standard scope controls for finalizing the specialized setup.

Save/recall of 30 setups

In many cases, several specialized setups need to be repeated for comparative measurements between test points or subsystems. With the 2445A and 2465A, these special setups need only be entered once and stored with the SAVE button and a memory location button. Then, when the front-panel setup is needed again, just press RECALL and the memory location button for the stored setup.

Eight setup memory locations are directly push-button selectable. An additional 22 setup storage locations can be accessed with a front-panel knob. Together, there are 30 locations for storing complete front-panel setups. The stored setups also include settings for the fully integrated 2445A and 2465A options — DMM, counter/timer, digital word recognizer, and video measurement system.

The capability for two-button recall of complex setups on an as-needed basis provides significant time savings over manually changing setups. It also eliminates the errors common in manually changing back and forth between setups.

In cases where several setups need to be executed in order, you can use the SEQUENCE feature. Sequences are defined by entering an END and a BEGIN marker in the setup memory. These mark a group of stored setups that can be executed in sequence by simply pressing a STEP button to bring up the next setting.

All 30 of the 2445A and 2465A memory locations can be used in a single sequence, or the memory can be divided into multiple sequences. Any sequence is called up by RECALLing the first setup in the sequence. From then on, setups are recalled in order by pressing the STEP button. Pressing STEP again after the last setup in a sequence has been executed causes the scope to loop back to the beginning of the sequence. This allows you to repeat a test or measurement setup sequence in cases where data needs to be taken for different operating conditions (e.g., temperature change, supply voltage change, etc.).

Built-in measurements, GPIB too

There are still other time saving features for systems applications. Various front-panel setups or setup sequences can be downloaded to the 2445A and 2465A scopes over a GPIB interface (when equipped with Option 10) as part of program initialization. Then, during regular program execution, the setups are recalled from local scope memory with simple commands. This reduces GPIB traffic considerably since complete settings transfers need only be done once as a download to the scope during program initialization.

The built-in measurement capabilities of cursors — plus the DMM, counter/timer, word recognizer, and video triggering options — offer still further automation simplifications. These measurement options specialize the 2445A and 2465A scopes, allowing many measurements to be made locally by the scope. Bus traffic can be reduced even further since final results are obtained by the scope itself. This can eliminate the need for full waveform transfers over the GPIB and external processing by a computer, all much more time consuming than processing by the scope.

Of course, there are some cases where waveform digitizing and fully automatic processing are easily justifiable. For these full-automation applications, a digitizing oscilloscope is warranted. But in many other cases — such as short-run production test, calibration, and engineering bench applications — the automation benefits of an analog scope can be put to good use without the burden of full ATE expense or cost justification.

In fact, setup transfers between 2445A and 2465A scopes can even be made using the GPIB interface option without a computer (see Figure 4). All that's required is a GPIB cable and a GPIB interface (Option 10) in each scope. A special push-button sequence allows test engineers to directly transfer setups or setup sequences between scopes over the GPIB cable. An additional push-button sequence also allows the setups to be write protected in each scope. As a result, test engineers have the ability to quickly and easily load the same front-panel setups or sequences into the scopes at various calibration or test bays.

Figure 4. *Setups can be transferred between 2445A and 2465A Option 10 scopes over the GPIB without a controller.*

For more information

To find out more about these and other automation features and applications of the new portable analog oscilloscopes from Tektronix, contact your local Tektronix Sales Engineer or representative. Or check the appropriate box on the **HANDSHAKE** reply card for a brochure.

These instruments can be ordered through the Tektronix National Marketing Center. Call 1-800-426-2200 toll-free (in Oregon call 627-9000 collect) and tell them you saw it in **HANDSHAKE.**

2467 Oscilloscope shares 2465A features

Tektronix 2467 Oscilloscope shares the features and characteristics of the 2465A, plus it includes a microchannel plate CRT

The recently introduced 2467 Oscilloscope shares all of the features and characteristics of the 2465A, plus it includes a microchannel-plate (MCP) CRT. The MCP provides high visual writing rate to provide a bright display of fast signals. It can display single-shot, 1-nanosecond pulse transitions in normal room light — even at 500 picoseconds/division sweep speed. This allows full use of the 350 MHz bandwidth. See **All this and programmable too!** in the Summer 1986 **HANDSHAKE**, Vol 11 No. 2 for further details on the 2467 and the microchannel-plate CRT.

To find out more about the 2467, please contact your local Tektronix Field office or sales representative. For a brochure, check the appropriate box on the **HANDSHAKE** reply card in this issue. The 2467 can also be ordered through the Tektronix National Marketing Center; 1-800-426-2200 toll-free (in Oregon call 627-9000 collect) and tell them you saw it in **HANDSHAKE.**

Signal processing tools for your IBM PC

The personal computer is becoming a standard fixture in many research and development laboratories. But current software offerings don't answer the needs for signal processing with these personal computers. Software is required that includes powerful waveform processing tools, a rich graphic display environment, and accessible data structures.

To answer these needs, Tektronix introduces Signal Processing and Display (SPD) software. This software includes powerful signal processing algorithms, enhanced graphics capabilities, and flexible data structures.

Based on proven signal processing tools developed by Tektronix over the past 15 years, SPD software includes over 190 different signal processing and analysis functions in formats available to users at every programming level.

A choice of formats

Signal Processing and Display software is written in the "C" programming language for efficiency. Figure 1 provides a graphic overview of the structure of SPD software. At the core is the SPD C Functions Library. This library consists of waveform processing functions, waveform manipulation utilities, and graphic display functions written in the "C" language.

The functionality of SPD software can be tapped in three different ways, depending upon the user's programming skills and environment — Menu interface, BASIC interface, or "C" language environment.

Menu interface allows fast solutions without programming. An easy-to-use menu-driven mode has been designed to provide ready access to all signal processing and display functions without having to write programs. This gives the user who is new to programming and signal processing a starting point to become familiar with SPD before moving on to more sophisticated applications. At the same time, the menu mode may be as far as many users ever need to go since it satisfies many routine lab applications.

BASIC interface allows SPD signal processing and graphic display functions to be included in test programs written in BASIC. This is especially convenient for those applications with existing compiled BASIC test programs or for those who feel most comfortable writing in BASIC. Most, but not all, of the data structure and waveform manipulation functions can be called through this interface.

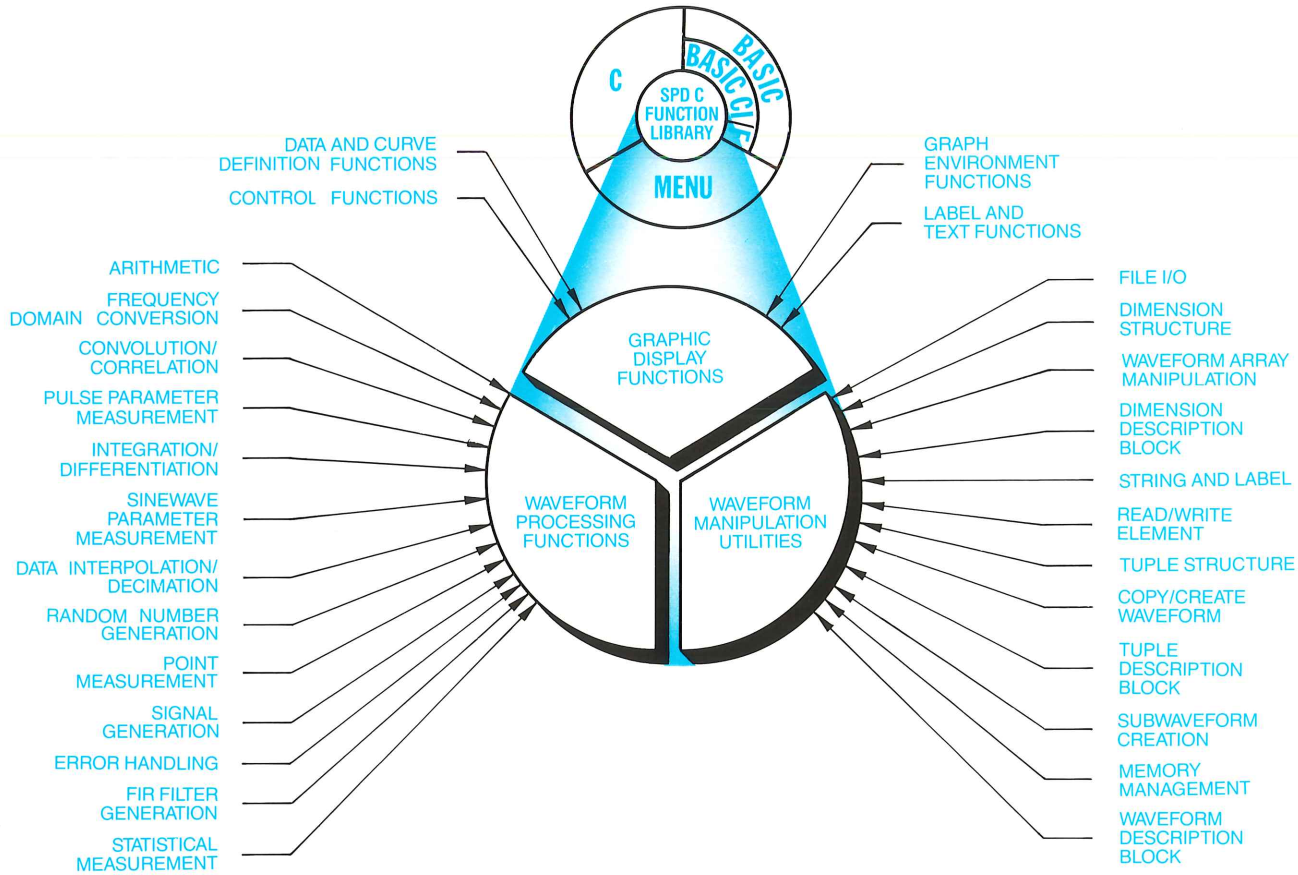

Figure 1. *Graphic overview of the structure of SPD software.*

"C" language environment offers the most speed and flexibility in accessing all functional and data structure manipulation utilities within the program. All waveform processing, graphic display functions, and data structure manipulation utilities are written in "C" and are directly callable from a "C" program (Lattice C, version 2.15). As the native language of SPD, the "C" environment offers the most power for signal processing and display.

Signal processing variety

Signal Processing and Display software offers a versatile signal processing toolset. This software includes 196 processing, analysis, and display functions. Figure 2 lists the function categories provided and the number of routines in each.

As an example of the signal processing power of SPD, consider the pulse parameter routines available. SPD contains 13

196 SOPHISTICATED SIGNAL PROCESSING AND DISPLAY FUNCTIONS PUT POWERFUL ANALYSIS CAPABILITIES ON YOUR PC

Description	Number	Description	Number
Arithmetic Functions	21	Tuple Structure	7
Frequency Domain Conversion	5	Graphics Control	12
Integration/Differentiation	2	Data and Curve Definition	12
Data Interpolation/Decimation	2	Graphic Environment	13
Random Number Generation	9	Label/Text Features	6
Signal Generation	4	File I/O Utilities	5
FIR Filter Generation	1	Waveform Array Utilities	5
Statistical Measurements	3	String/Label Utilities	6
Sine Wave Parameters	1	Read/Write Element Utilities	2
Pulse Parameters	13	Create/Copy Waveform Utilities	5
Point Measurements	2	Subordinate Waveforms	4
Waveform Header Block Macros	17	Dimension Structure	7
Tuple Description Block	8	Dimension Block Macros	8
Convolution/Correlation	3	Memory Management Utilities	6
		Error Handling Functions	9

Figure 2. *Function categories and number of routines available in SPD software.*

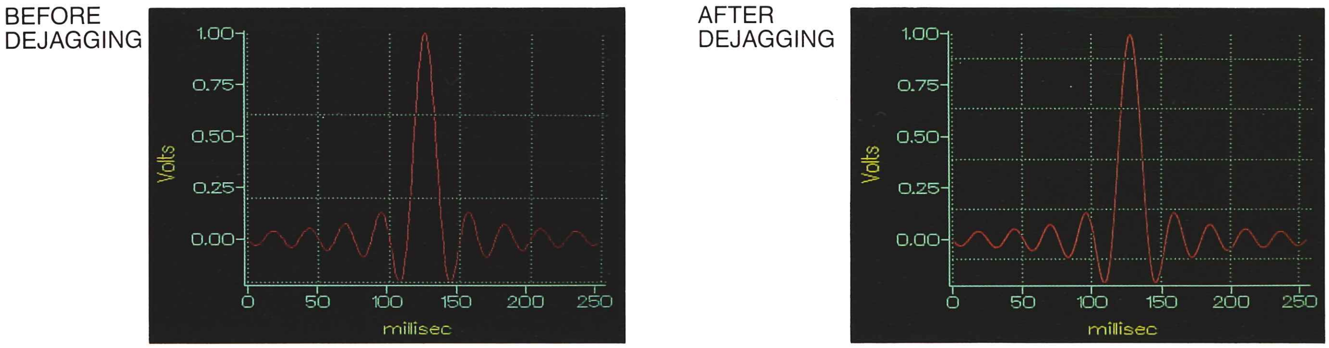

Figure 3. *Comparison of normal raster-scan waveform (left) to same waveform (right) processed with the SPD "dejagging" algorithm. This can be used on PCs equipped with the IBM Professional Graphic Adapter (PGA).*

functions for pulse characterization including period, amplitude at midpoint, positive and negative peak value, 50% transition level on leading or trailing edge, risetime, falltime, duty factor, and overshoot. You can also measure the rising or falling distal, mesial, and proximal points. In addition, a histogram routine is provided to calculate the top and bottom values for a pulse.

Graphics to display your results

The SPD graphics environment offers a rich selection of display capabilities including multiple displays, grids, and colors. Graphic functions available include graphic control, data and curve definition, environmental definitions, labels, and text. All waveform display functions are available in both the BASIC and "C" programming environments.

A Tek-patented anti-aliasing algorithm overcomes the annoying "pixel staircase" look of waveforms displayed on raster-scan monitors (see comparison between waveforms shown in Figure 3). The algorithm "de-jags" the waveform, smoothing it for high readability and more accurate analysis — particularly important for displays with dense graphic content. Users can invoke this function on systems with the IBM Professional Graphics Adapter.

Flexible data structures

The waveform data structure of SPD software permits you to store and describe multi-dimensional data arrays with each dimension independent of the others. You can readily look at data from more directions and in greater detail — even down to the tuple level (a tuple is a single datum — a single quantity at a single point in a single dimension).

Even for each tuple, SPD stores an array of information. A ***type*** defines tuple data storage characteristics; a ***label text string*** describes it; a ***scale factor*** yields values in tuple units; an ***offset factor*** is a number that is an additive offset for the tuple data value in tuple units; and ***units*** are text strings that name units in which the tuple values were measured (e.g., volts).

Besides measurement and tuple data, SPD can store titles of waveform data in words, notes (text strings) of your comments, a label for each waveform dimension verbalizing the dimension, a scale factor representing the sampling interval between elements, an offset factor quantifying the distance from coordinate system origin to first element, and units of text strings that define measurement units.

System requirements

The following minimum system configuration is required to run SPD software:

Required hardware:
- IBM PC, Portable PC, PC/XT, or PC/AT.
- 256 Kbytes memory (640 Kbytes recommended).
- One double-sided, double-density disk drive.
- 10 Mbyte hard disk highly recommended.

Graphics requirements: One of the following display cards with corresponding IBM PC color graphics display:
- IBM Color Graphics Adapter.
- IBM Enhanced Graphics Adapter.
- IBM Professional Graphics Adapter.

Optional hardware:
- 8087 or 80287 math co-processor.
- IBM plotter.

Required software:
- IBM PC-DOS, version 2.1 or higher.

Optional software:
- Lattice C, Version 2.15.
- IBM Compiled BASIC, Version 1.0.
- Tektronix driver utilities.

Ordering information

To order SPD software, call the Tektronix National Marketing Center, 1-800-426-2200 (in Oregon call 627-9000 collect), and ask for the 10Z210 Signal Processing and Display Programs Software package. And be sure to tell them you saw it in **HANDSHAKE**.

For a brochure describing Tektronix Signal Processing and Display software, use the **HANDSHAKE** reply card included in this issue.

Add programmability to your curve-tracer measurements

An old standard gets updated

Tektronix curve tracers have been accepted as the standard for semiconductor measurements for many years. This standard is being updated with the introduction of the Sony/Tektronix 370 Programmable Curve Tracer to include GPIB programmability, bubble memory storage of characteristic curves and front-panel setups, and more.

Familiar operation

For those familiar with the operation of a curve tracer, making measurements with the 370 is easy. This is because the 370 front-panel layout and control labels resemble its predecessors. But added to this familiar look and feel are features that will enhance and extend your semiconductor characterization measurements and improve your testing productivity.

For example, up to 16 front-panel setups can be stored in an on-board bubble-memory cassette. This allows even an inexperienced operator to get the correct front-panel setup at the touch of a button. As an additional help, up to 16 waveforms (characteristic curve families) along with associated readout parameters can also be stored in the bubble-memory cassette. These waveforms can include "known good" references which the operator can recall for simultaneous display and comparison against the current display.

More information from your display

The 370 incorporates a variety of features which allow you to easily and conveniently obtain data from the characteristic curve display. Some of these features are:

Digital storage display mode provides bright, stable, flicker-free displays. Non-store mode is also available for conventional curve-tracer displays.

CRT readout puts front-panel settings data and measurement results on the display area along with the displayed waveforms. Readout information displayed includes vertical and horizontal scale factors, voltage/current step and offset amplitudes, auxiliary voltage setting, beta, transconductance (G_m), and cursor coordinates. A message area allows operator prompts to be displayed.

Cursor measurement mode allows dot or crosshair cursors to be positioned anywhere on the CRT for precise current and voltage measurements. Vertical and horizontal coordinates of the cursor position are displayed by the CRT readout.

Envelope mode saves and displays the minimum and maximum excursion of individual curves over time. This is particularly useful for tracking long-term changes in device characteristics such as thermal drift.

Window mode allows visual "pass/fail" or "go/no-go" testing. A rectangular test-limits window can be positioned anywhere on the waveform area. And the window can be stored along with the front-panel setup so an area of the display is "high lighted" for the operator.

Averaging mode reduces the effects of random noise which tends to mask the desired curve data on high-sensitivity ranges.

A choice of output

The 370 provides a variety of methods to output data. In addition to the normal CRT display of characteristic curves, the CRT readout displays front-panel settings and values. A message area allows up to 24 characters for operator prompts.

Waveforms and front-panel settings can be stored on the removable bubble-memory cassette. This means you can store setups and displays for later recall or for transfer of test information between test stations.

For high-quality hard copies of displays, a plotter can be connected to the plotter output. This output is an eight-bit parallel (Centronics standard) interface which conforms to Hewlett Packard graphics language (HPGL) commands so it can be used with a variety of plotters. Characteristic curve data only or CRT readout and graticule data can be included on the plot for record-keeping purposes.

Front-panel settings and waveforms can be transferred to other devices for further analysis and processing over the IEEE-488 (GPIB) bus. Among other functions, this allows integration of characteristic curves from the 370 with data from other sources.

All under program control

All of the 370 functions (except those controls which require operator adjustment such as intensity and focus) can be controlled by a system controller over the IEEE-488 (GPIB) bus. The GPIB interface complies with the Tektronix Interface Standard for GPIB codes, formats, conventions, and features. This allows the 370 to be a part of a fully-automated test system. In addition, waveforms can be transferred to the controller for storage or more in-depth analysis. Also, the controller can display operator messages or measurement results in the message area of the CRT.

For more limited semiautomatic testing, the 370 can be sequenced through as many as 16 complete tests stored in the bubble-memory cassette. Additional interchangeable cassettes may be used for tests with more than 16 steps.

For more information

This is only a brief overview of the 370 Programmable Curve Tracer. To find out how this instrument can improve your semiconductor characterization measurements, please contact your local Tektronix Field Office or the sales representative for your country. For a brochure describing the 370, use the **HANDSHAKE** reply card included in this issue.

Get an assist in your signal processing measurements

Tektronix is now offering ASYST, a fully-integrated software tool which provides the user with the most commonly used data acquisition, statistical, graphing, and analysis capabilities required in engineering and scientific applications. ASYST, a product of the MacMillan Software Co., has found wide acceptance in many engineering and scientific laboratories. And now, the power of Tektronix signal acquisition instruments has been combined with the processing power of ASYST.

A modular approach

ASYST is designed as separate, fully-integrated modules. As offered by Tektronix, ASYST includes Module 1 — System/Graphics/Statistics, Module 2 — Analysis, and Module 4 — GPIB/IEEE-488. An optional 7000-Series Drivers package is available from Tektronix.

Module 1 — System/Graphics/Statistics establishes the environment. It provides basic mathematics operators, descriptive statistics, array manipulation and control, automatic plotting and color graphics support, a text editor, file I/O, and a built-in programming language.

Module 2 — Analysis reduces and analyzes data. Includes eigenvalues, eigenvectors, polynomials, ANOVA, axonometric and contour plotting, least squares approximations, curve fitting, convolutions, integration, differentiation, smoothing, and fast Fourier transform.

Module 4 — GPIB/IEEE-488 allows interfacing to a wide variety of instruments which conform to the IEEE-488 standard (optional GPIB driver card required).

7000-Series Drivers provide a function-key driven program that allows for the acquisition and storage of waveforms, storage and retrieval of settings or programs, zoned pulse parametric analysis (max, min, mid, peak-to-peak, risetime, falltime, overshoot, undershoot, pulse width, period, crossing levels), and frequency domain analysis. Written in the

ASYST language, the 7000-Series Drivers allow a user to get up and running fast for pulse parametric analysis applications. It also provides a framework from which the user can develop additional applications. 7000-Series Drivers software is part of the Tektronix TekMAP software series and provides support for the Tektronix 7D20 Programmable Digitizer and the 7854 Waveform Processing Oscilloscope with support for other Tektronix digitizers such as the 2430 Digital Storage Oscilloscope to be added in the near future.

Software to grow with

ASYST is designed so that it can be used by novice users with a minimum of introduction, while allowing the advanced user to take full advantage of its powerful programming language. Users with minimal computer background can quickly perform tasks that would otherwise require days of sophisticated programming, while advanced users can take advantage of ASYST's full programmability to create custom applications.

Since ASYST is offered unmodified, it can be used with other modules available from MacMillan Software Co. or used with other applications developed for ASYST.

System requirements

The following minimum system configuration is required to run ASYST software:

Required hardware;

- IBM PC, PC/XT, or PC/AT.
- 640 Kbytes memory.
- Two or more drives (including one double-sided, double-density disk drive).
- IBM Color Graphics Board, IBM Enhanced Color Graphics Board, or Hercules Graphics Card.
- 8087 or 80287 math co-processor.
- GPIB Board (Tektronix GURU; National Instruments GPIB-PC, PC-2, or PC-2A; IBM; Capital Equipment; or MetraByte IE-488).

Required software;

- IBM PC-DOS, version 2.1 or higher.

Optional software;

- Tektronix S42P302 7000-Series Drivers for ASYST, Option 01.

Optional hardware;

- IBM graphics printer.
- Hewlett-Packard 7470 or 7475 plotter.
- Gould Colorwriter plotter.

Ordering information

To order ASYST software, call the Tektronix National Marketing Center, 1-800-426-2200 (in Oregon call 627-9000 collect), and ask for S42P301 ASYST Modules 1, 2, 4, Option 01. For the ASYST drivers for the Tektronix 7D20 and 7854, ask for S42P302 7000-Series Drivers for ASYST, Option 01. And be sure to tell them you saw it in **HANDSHAKE**.

For a brochure describing ASYST, use the **HANDSHAKE** reply card included in this issue.

We're interested in hearing from you

Are you a user of programmable instruments? Do you use digital signal processing techniques in your job? Do you have an interesting application that you would like to tell others about? Have you written a program that solves a unique measurement problem? Do you have operating hints or tips you would like to share with other users?

If you answered yes to any of these questions, **HANDSHAKE** would like to hear from you. **HANDSHAKE** is your newsletter of signal processing and instrument control and our continuing goal is to make it as interesting and informative as possible. One of the best ways to do this is through articles describing real-life applications as experienced by our readers.

Writing an article for **HANDSHAKE** is a lot easier than you think. Just provide a simple description of the application or measurement problem, how you solved it, equipment you used, and why you feel this solution is unique or important. Include any supporting material such as block diagrams, programs, waveforms, photographs, etc. If you need assistance in writing your article, the **HANDSHAKE** Staff will be glad to help in any way we can.

All articles accepted for publication in **HANDSHAKE** will carry full credit to author and company.

Address articles, article ideas, or programs to:

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Beaverton, OR 97077

If you would rather talk to us about your idea, feel free to call between 8 am and 4:30 pm (pacific time) at the following number:

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Or check the box on the **HANDSHAKE** reply card included in this issue indicating that you have an article idea. We'll be in touch with you promptly.

Putting ASYST to work ...

Engine performance measurements

Paul Kristof
Application Software Manager
Laboratory Instruments Division
Tektronix, Inc.

The best test of any software is its actual performance on the job — how does it perform in your application. With this article we would like to show the ease of setting up an application with ASYST and the ability to tailor the solution for multiple applications. A detailed program listing is not provided here but only program excerpts to illustrate the process of designing a solution using ASYST.

The application

To illustrate, let's look at a typical application involving the acquisition of two waveform arrays — evaluating the performance of a single-piston internal-combustion engine. Suitable transducers are used to acquire data commonly available from engine test setups — pressure, volume, and RPM (for trigger input).

From the input data, dV/dt (the change in volume with respect to time) is calculated. Then the pressure data is multiplied by the differentiated volume signal to obtain the instantaneous power per degree of rotation. This result is then integrated over two revolutions (720 degrees of rotation) to obtain the value of work performed. With appropriate scaling, IMEP (indicated mean effective pressure) and horsepower can be computed and displayed.

Defining the solution

The first task in developing a system solution is to define what the system needs to do. The short time it takes to layout the system on paper avoids wasted time due to false starts and promotes designing a system that is both extendible and maintainable.

In analyzing this application, the primary goal is to be able to determine the horsepower of the engine under test. However, several other system requirements can also be identified:

- To acquire data, compute, and display the results with a single keystroke.
- To display intermediate results of the waveform computations as they are being performed.
- To easily modify the sequence of steps being performed and interactively perform additional analysis.
- To provide a framework of procedures to use with similar applications in the future.

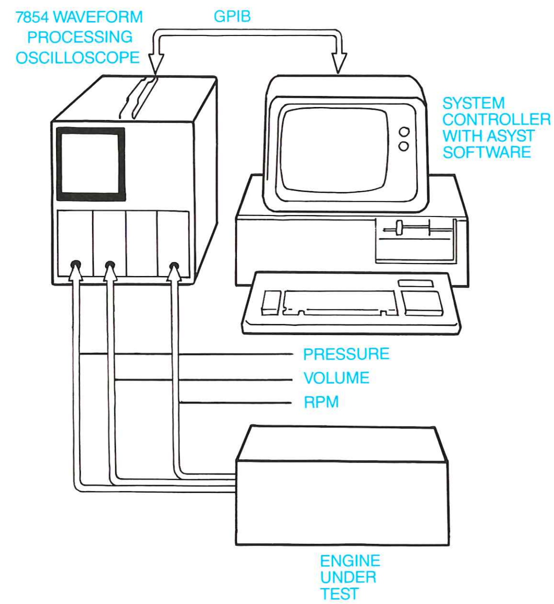

Figure 1. *Test setup for acquiring data.*

The system

Figure 1 shows a block diagram of the system setup required for this application.

The system controller chosen is an IBM PC/AT with 640K memory, 80287 math co-processor, enhanced graphics adapter, and a Tektronix GURU GPIB card (GURU software not used).

ASYST, a product of the MacMillan Software Co., is used for the system software (see preceding article **Get an assist in your signal processing measurements).** ASYST is a word-definition oriented language which allows you to assign a sequence of events or program steps to a word (in ASYST, a word is any series of characters, single words, or combination of words separated by a period). ASYST has a rich base of about 920 pre-defined words. For this application, we will define several additional words to acquire, process, and display the waveforms of interest. For parameter passage we will use both ASYST's built-in numeric stack and variable definitions.

A digitizing oscilloscope acquires pressure and volume data using transducers connected to a working engine. A Tektronix 7854 Waveform Processing Oscilloscope was used for this example although other digitizing oscilloscopes could be substituted.

Module 4 of ASYST along with the Tektronix GURU board provides data acquisition through the GPIB interface of the digitizing oscilloscope.

Figure 2 shows a simplified structure chart of the software required to accomplish this task.

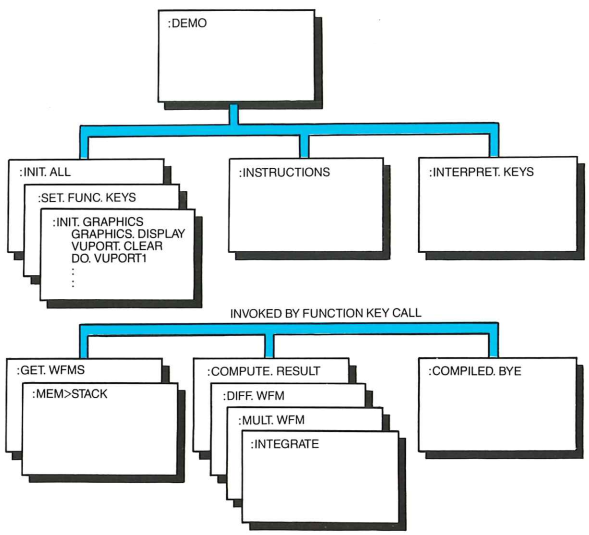

Figure 2. Simplified structure chart of system software.

Data acquisition and processing

The oscilloscope allows two channels of data acquisition, so we will define a word that transfers a waveform, identified by the channel number placed on the stack, to an array on the numeric stack. We can then normalize the data by converting it from binary levels to actual floating-point voltage values. The MEM>STACK word definition does this for us (details of MEM>STACK not given here for brevity).

Now, we define the word GET.WFMS that uses MEM>STACK to acquire channel 1 and 2 and stores the data in memory locations PRESSURE and VOLUME respectively. Definition of this word is (comments on program lines follow the "\"):

```
: GET.WFMS            \Read and store waveforms
   0 MEM>STACK        \Read channel 1 from scope to stack
   PRESSURE :=        \Save as pressure data

   1 MEM>STACK        \Read channel 2 from scope to stack
   VOLUME :=          \Save as volume data
;
```

At this point, we can acquire the necessary data arrays from the digitizer and save them in variables for later usage. An important point is that we have defined new words or commands we can use later in interactive mode to acquire data for processing. After the data is acquired in voltage units, conversion factors are used to display pressure data in pounds/square inch (psi) and volume data in cubic feet.

Display management

Once we have entered data, it is highly desirable to view the results of our labor. By using ASYST screen management functions, we can define multiple viewports on the screen and reference them through labels. ASYST automatic graphing functions work in the currently active viewport. Each viewport has its own graphics attributes associated with it. In this example, we will define five separate viewports on the screen (see Figure 3). Four of them, labeled VU1 to VU4, display the acquired data and intermediate results. The other displays a function-key menu and interactive mode text. Word definition required to produce viewport 1 is:

```
: DO.VUPORT1          \Define viewport 1
   VU1
   VUPORT.CLEAR
   1 VUPORT.COLOR     \With a blue background
   10 COLOR           \And a light-green plot
   .5 .4 VUPORT.SIZE  \Set viewport dimensions
   .0 .6 VUPORT.ORIG  \In the upper left-hand quadrant
;
```

With these definitions, we can now select which area to place our waveform graphics in by simply invoking a single word VUn. Because our system includes an enhanced graphics adapter, each area and graphics can be displayed in a different color.

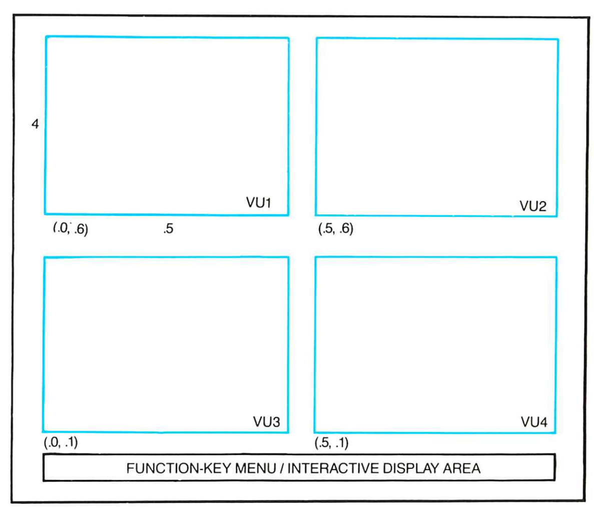

Figure 3. Five viewports used to display data. Each viewport area shows the parameters used in program to set up that viewport.

Data acquisition and display

Now we are ready to acquire and display data. The following word definition acquires the pressure and volume data and displays it in viewport 1:

```
: ACQ.DISP.DATA          \Acquire & convert waveform data
  GET.WFMS               \Get data
   CON.PRESSURE          \Convert to psi
   CON.VOLUME            \Convert to cubic feet

  REVS                   \Plot pressure vs revolutions
  PRESSURE               \Place arrays on stack
  VU1                    \Select viewport 1
  XY.AUTO.PLOT           \Plot pressure vs revolutions

  REVS                   \Plot volume vs revolutions
  VOLUME                 \Place arrays on stack
  VU1
  XY.DATA.PLOT           \Plot new array over existing plot

  NORMAL.COORDS          \Label graph
  .25 .85 POSITION       \Set label position
  "‸PRESSURE"‸ LABEL     \Plot label string
  .65 .85 POSITION       \Set label position
  "‸VOLUME"‸ LABEL       \Plot label string
  INSTRUCTIONS           \Redraw function key sequence
;
```

The word INSTRUCTIONS is defined to clear the bottom of the screen used for the function key menu and re-display that menu.

Computations

Once we have setup the base definitions to acquire and display data, the computations follow quite easily. The word DIFF.WFM definition requires the data array to be differentiated and to be placed on the stack. DIFF.WFM then performs the differentiation, displays the result in viewport 2, and labels it. For each computation step, we define a word to perform the desired operation. Definition of DIFF.WFM is:

```
: DIFF.WFM               \Differentiate data array on stack and
                          display results
  1 SET.ORDER
  3 SET.DEGREE
  DIFFERENTIATE.DATA     \Differentiate data
  DIFF.WFM :=            \Save result

  REVS                   \Place revolutions and differentiated data
                          on stack
   DIFF.WFM
   VU2                   \Select viewport 2
   XY.AUTO.PLOT          \Display differentiated data vs revolutions
   NORMAL.COORDS         \Label graph
   .25 .85 POSITION
   "‸d(volume)/dt"‸ LABEL
   INSTRUCTIONS
;
```

Finally, we define a routine COMPUTE.RESULT which is a combination of all the computations, and attach its usage to function key 1 by using F1 FUNCTION.KEY.DOES COMPUTE.RESULT (details not shown for brevity). Figure 4 shows the final result, including the function-key menu.

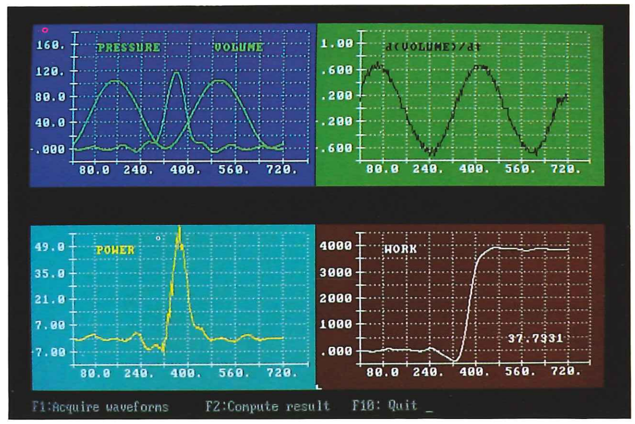

Figure 4. Final output from engine-analysis program.

Interactive usage

The program defined here can be operated through the function keys or in an interactive mode. By returning ASYST to the "OK" prompt level, we can use the words we have previously defined. For example, to plot pressure versus volume and display it in viewport 1, we could use the acquired data as follows:

```
VU1                 \Set viewport
PRESSURE            \Place data on stack
VOLUME              \Place data on stack
XY.AUTO.PLOT        \Plot results
```

The viewport definitions can be reused for similar applications, as can the GET.WFMS and MEM > STACK definitions. Additional functions can be easily added by including their definition in the function display and setup definitions.

Conclusion

Personal computing has opened many new avenues for today's engineers and researchers. Software packages such as ASYST have provided the vehicle for them to easily explore these avenues. By providing a fast, flexible, and rich environment — all in one integrated system — ASYST enhances the productivity of the user.

For more information on this application or for information regarding availability of a full program listing, contact the author at:

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M/S 39-327
Beaverton, OR 97077
(503)627-2746

The author wishes to acknowledge the assistance of Fernando Martinez, Applications Engineer, Laboratory Instruments Division, Tektronix, Inc., in developing the program to make this application possible.

Customer training classes and workshops

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

IG Customer Training workshops allow you to get the maximum usage out of your equipment investment. In addition, these workshops give you a new perspective on your applications and provide new methods for making measurements.

CLASS	LOCATION	DATES
Analog Realtime Oscilloscope Workshops		
XYZ's of Using a Scope (based on the 2200 Series)	Seattle	Feb 3
	Washington DC	Feb 17
	Beaverton	Mar 3
Parametric Measurements and Advanced Parametric Measurements (using the 2465A Oscilloscope)	Los Angeles	Dec 10-11
	Seattle	Feb 4-5
	Washington DC	Feb 18-19
	Beaverton	Mar 4-5
Digital Storage Oscilloscope Workshops		
Basic Digital Fundamentals (using the 2230 Oscilloscope) and Advanced Digital Measurements (using the 2430 Oscilloscope)	Philadelphia	Nov 18-20
	Cleveland	Dec 3-4 (2430 only)
	Santa Clara	Jan 20-22
	Dallas	Feb 24-26
Waveform Processing (using the 7854 Oscilloscope)	Boston	Nov 19-20
	Dallas	Nov 19-20
	Cleveland	Dec 3-4
	Indianapolis	Dec 3-4
	Irvine	Jan 13-14
	Santa Barbara	Jan 27-28
	Woodbridge	Jan 28-29
	Raleigh	Feb 11-12
	Beaverton	Feb 24-25
Advanced Waveform Processing (using TEK SPS BASIC, 7612D Digitizer, 7912AD Digitizer)	Beaverton	Dec 9-12

Controllers and Other Workshops		
High-Speed Measurements Using Sampling Techniques	Boston	Nov 21
	Irvine	Jan 15
	Santa Barbara	Jan 29
	Beaverton	Feb 26
Using a 4041 Controller for Automation	Philadelphia	Dec 2-4
	Irvine	Jan 13-15
	Beaverton	Feb 17-19
Using a PC as a Controller	Philadelphia	Dec 5
	Irvine	Jan 16
	Beaverton	Feb 20

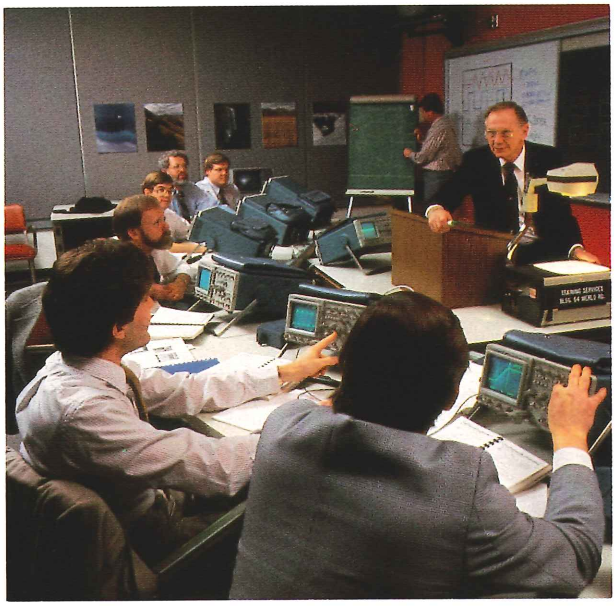
In addition to regularly scheduled workshops, Tektronix also offers private workshops that can be conducted at your location. Call for further information.

Registration information

Workshop sizes are limited. We recommend that you enroll early.

For more information or to register for these workshops, call Tektronix IG Customer Training, 1-800-225-7802 (in Oregon, call 642-8013), or contact your local Tektronix Field Office.

We retain the option to cancel or reschedule a workshop.



Service Training Classes

Tektronix Service Training provides new technicians the skills and techniques required for effective maintenance of Tektronix products. In addition, it brings experienced technicians up to date on maintenance of new products.

CLASS	LOCATION	DATES
465B/475A Portable Oscilloscope	Boston Washington DC	Jan 5-9 Apr 27-May 1
2465 Portable Oscilloscope	Boston Chicago Irvine	Nov 10-21 Jan 26-Feb 6 Apr 27-May 8
2430 Portable Digital Storage Oscilloscope	Beaverton	Mar 9-20
7612D Programmable Digitizer	Beaverton	May 11-22
7854 Oscilloscope	Beaverton	Jan 26-Feb 6
7904 Oscilloscope/7633 Storage Oscilloscope	Denver Boston Chicago	Jan 19-30 Mar 23-Apr 3 Apr 27-May 8
7912AD Programmable Digitizer	Beaverton	Jan 26-Feb 6
CG 5001 Programmable Calibration Generator	Beaverton	Feb 16-20
TM 500 Calibration Package	Denver	Dec 1-5
TM 5000 Digital Counter/ Digital Multimeter	Beaverton	Call for schedule
TM 5000 Multifunction Interface/Function Generator	Beaverton	Nov 10-21
TM 5000 Signal Generator/ Distortion Analyzer	Beaverton	Mar 9-20

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

Registration information

Class sizes are limited. We recommend that you enroll early.

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Whether your need is for software development tools, specialized software utilities, or applications packages, Tekware can reduce your software development time and costs.

Development Software

Tekware development software tools can be used to create new software or to modify existing software. Some Tekware development software products contain test program generators enabling you to create test procedures without writing a single line of code.

If your testing requirements call for development of a custom program or for customizing an existing program, a Tekware development software tool could be the key to the solution.

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Tekware utility software instrument drivers, peripheral drivers, processing modules, and display modules can be linked to other Tek or non-Tek software to produce custom programs. Using Tekware utility software whenever possible, rather than developing your own code, can substantially reduce software development time.

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Applications Software

Tekware applications software provides a wide selection of ready-to-use general purpose control, measurement, and display capabilities. Simply load Tekware applications into your controller, and your system is ready to go to work for you. If your software requirements do not call for unique processing or specialized control functions, Tekware applications software could be the shortest path to a complete system solution.

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Keep a clean screen

CRT static charge: What causes it? How do we get rid of it? We've all seen the effects. Just draw your finger across the faceplate of your TV or terminal and listen for the crackling sounds. Or look at the trail in the dust you've just drawn. All that static charge does attract a lot of dust. But why?

CRTs are insulating bottles, filled with vacuum, conductors and phosphor, connected to a high voltage, inside a magnetic shield. If you think about that for a second, it's a description of a high-voltage capacitor, with a large side of it exposed to the outside world. The other side of that window is covered with an aluminized phosphor, connected to a high voltage, being painted with electrons. All that electrical activity attracts dust from the room, especially in the winter, when the air is dry. Dry air is a better insulator. The surface of the CRT is also a better insulator, because it's dryer too. Charge on the dust particles can't leak off either.

What's the solution? Soap solution. (Sorry.) The trick is to get the CRT surface conducting again, so the collected charge can leak off. In the summer, when it's humid, there is enough moisture in the air to provide a film. We can clean the dust off with a mild detergent; then just don't continue wiping. Leave the soap film. It will then keep a little moisture film on the surface to bleed away the charge.

If soap film doesn't do it, you might try a glycerine solution. Glycerine attracts moisture somewhat better than soap. Make the solution rather weak; we don't want the CRT looking like it was smeared with vaseline.

Won't this film make dust stick better? Well, maybe, but less will be attracted to the reduced charge. There is no solution that will avoid the need to clean your screen. Just restore the film afterward.

Thanks to Ed Caryl, Portable Instrument Division, Tektronix, Inc., for this maintenance tip.

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