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Tekscope

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COMMITTED TO EXCELLENCE

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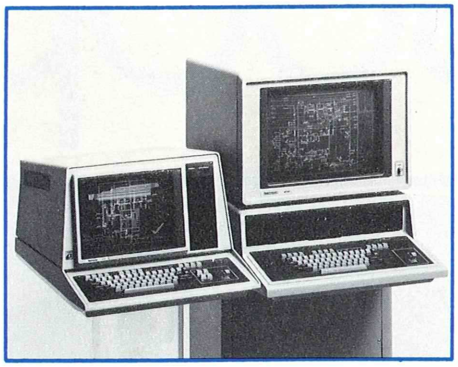
High resolution, color-enhanced refresh, and greater interactivity are combined in a new 19-inch DVST graphic terminal. A software-compatible 15-inch raster-scan terminal provides zoom and pan functions, multiple viewports, and multiple-bit planes for gray scale and overlays.



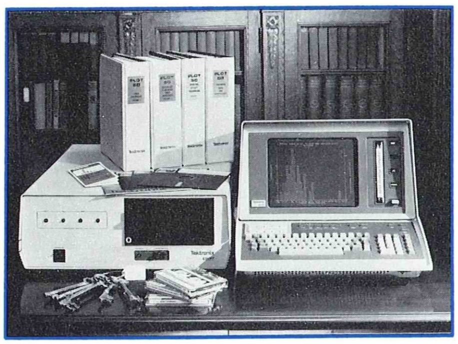
Customer information from Tektronix, Inc.
Beaverton, Oregon 97077

Tekscope is a quarterly publication of Tektronix, Inc. In it you will find articles covering the entire scope of Tektronix' products. Technical articles discuss what's new in circuit and component design, measurement capability, and measurement technique.

Editor: Gordon Allison
Graphic Designer: Michael Satterwhite

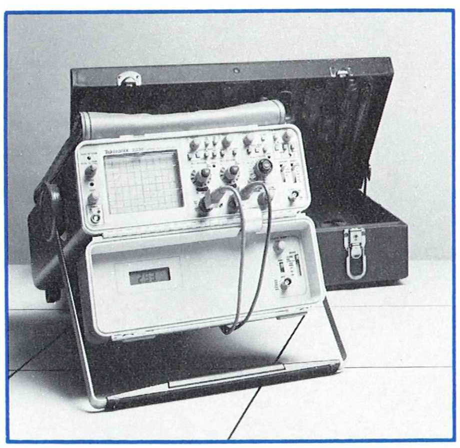
Software Innovations Increase Productivity of Desktop Computer Users

A new software library makes the graphic power of Tek's desktop computers available to users with little or no programming experience and enhances the productivity of skilled operators.



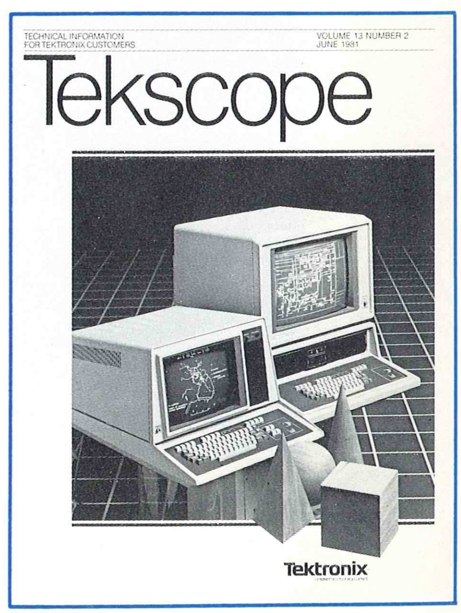
Three New Portable Oscilloscopes Designed for Field Service Use

Ruggedness, lightweight, and excellent EMI performance characterize the new 100-MHz 2300 Series Oscilloscopes designed expressly for field service applications.



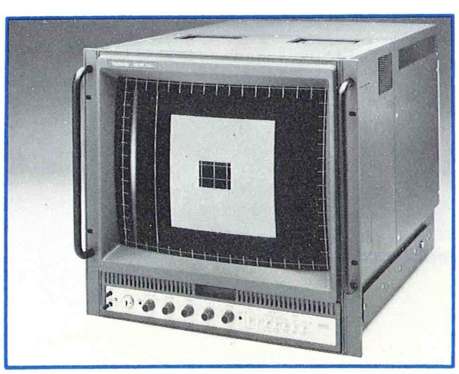
Cover

The 4114, 19-inch DVST and 4112, 15-inch raster-scan computer display terminals increase user productivity through the use of segments — basic display elements that are used again and again in a display and can be called up with a single command.



A High Resolution Color Picture Monitor for Television and Laboratory Use

The 690SR is a precise, stable, color picture monitor with a unique color-convergence system that makes set-up a simplified, straightforward procedure. Plug-in interface modules and wide range scan circuitry make the 690SR easily adaptable to specialized applications.



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Two New Graphic Terminals Expand Graphic Capabilities

Computer graphics users have varied requirements — so varied that no single display technology meets every need. The new Tektronix 4110 Series of graphic terminals offer users a choice of display technology: for high-density graphics, the high-resolution direct-view-storage-tube (DVST) display; and for dynamic graphics, the versatile raster-scan display.

Design goals for the 4110 Series were to expand on the capabilities of the current Tektronix 4010 Series, increase user productivity, decrease host communications traffic, and maintain compatibility with the 4010 Series and across the 4110 Series.

At introduction, two members of the 4110 Series were announced —the 4114 Computer Display Terminal, a 19-inch DVST terminal with refresh graphics and fast redraw capabilities, and the 4112 Computer Display Terminal, a 15-inch raster-scan terminal with zoom and pan functions, multiple-bit planes for gray scale and overlays, and multiple viewports (see Figure 1).

Compatibility maintained

The new capabilities of the 4110 Series were achieved without sacrificing compatibility with the 4010 Series. Host software designed for the 4010 can be used without modification with any 4110 Series terminal. As need for the expanded capabilities of the 4110 Series arises, the software can be modified accordingly.

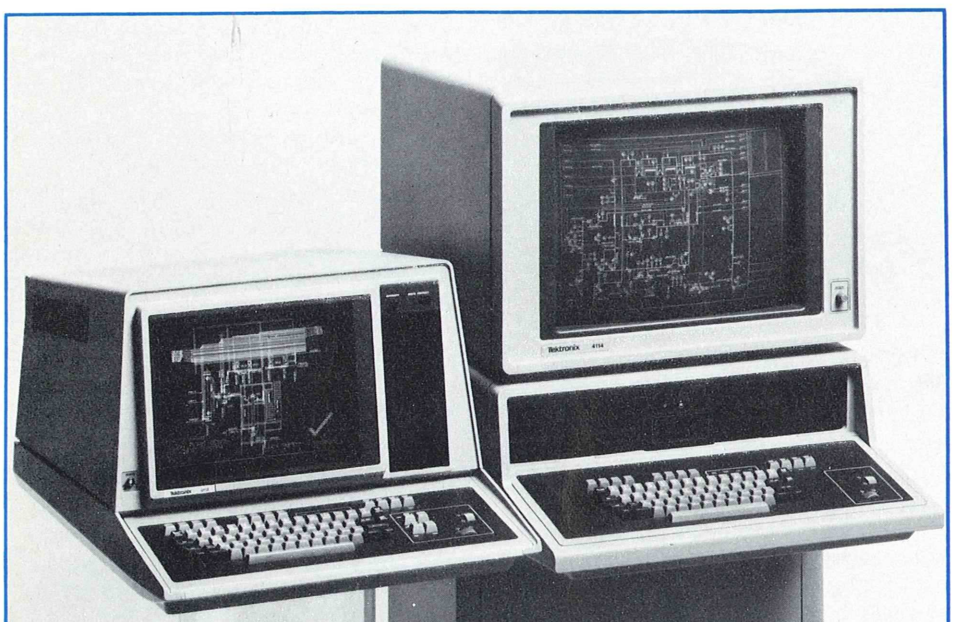


Fig. 1. The new 4112 raster-scan terminal (left) and the 4114 DVST terminal (right) provide users a choice of graphics display capability with features designed to greatly increase the user's productivity. The 4112 and 4114 are software compatible with the 4010 Series terminals.

Even though the 4112 and 4114 use different display technologies, host software written for one terminal can be used without modification on the other. Compatibility also extends to the hardware — both terminals use an identical 16-bit microprocessor, a common bus structure, and identical mass storage. Each terminal includes firmware and 32K bytes of random access memory (RAM), and memory can be expanded up to 1M bytes of ROM/RAM. Optional flexible disk drives add a permanent storage capacity of up to 512K bytes per disk.

Both terminals work with a common set of peripherals, such as digital plotters, hardcopy units, printers, and graphic tablets. The 4110 Series are also supported by the Tektronix PLOT 10 Interactive Graphics Library.

The 4112 and 4114 allow the user a device coordinate space of 4096 by 4096 addressable points; however, the actual display resolution (the number of points that can be displayed on the screen) depends on the size and type of CRT. The 4112's 15-inch raster-scan tube provides a displayed resolution of 640 by 480 points, and the 19-inch DVST of the 4114 a displayed resolution of 4096 by 3131 points. The host can send an identical picture to both terminals in a coordinate space of 4096 by 4096 points, and each terminal will locally map the picture onto the actual coordinate space of its CRT.

Local picture segments

Both the 4112 and 4114 possess two of the most significant features of the 4110 Series terminals — local picture segments and a scrollable dialog area. A picture segment, as described in SIGGRAPH-ACM's proposed core system of computer graphics standards, is an ordered collection of output primitives (for example, vectors or text strings) defining an image which is part of the picture on a view surface. Let's illustrate the concept of the use of picture segments with an example.

An engineer is using a 4110 Series terminal to design an electronic circuit. The host computer sends the graphics data to display representations of components, such as transistors, resistors, and capacitors, on the terminal's screen. Each component is stored in the terminal's memory as a separate segment. The segment is numbered and therefore can be specified independently of the other segments. The designer uses the terminal keyboard controls or a peripheral graphics input device (such as a graphics tablet) to select the desired component and position it on-screen. The component remains displayed at that position, while the designer selects and positions other components.

The capability to store and manipulate segments locally provides several benefits. Host communications traffic is substantially reduced as it is no longer necessary to retransmit the entire sequence of graphics data to the terminal. The host need send only a command that says, in effect, display segment **n.**

There is a marked increase in repaint speed (the rate at which an erased display can be redrawn). This capability is particularly valuable when working with DVST displays containing large numbers of vectors or alphanumerics. For example, a diagram containing 25,000 short vectors, stored in RAM, can be redrawn and stored on the 4114 screen in less than half a second.

Refresh augments storage

The 4114 DVST terminal is given a substantial interactive capability by employing local refresh for up to 3000 short vectors. There is no limit to the number of vectors that can be displayed in the storage mode. In contrast, the entire 4112 raster-scan display is refreshed.

Both the 4112 and 4114 can perform local two-dimensional image transformations. A segment may be rotated, translated (shifted in position), and scaled (made larger or smaller). The user has the flexibility to define a picture segment of a standard size and shape, and after it is displayed, modify its image to fit the application. For example, consider an architectural application. The host sends a standard segment displayed as a square. The square can be modified locally to become the exterior outline of the building. The same standard square, transmitted again by the host, can be manipulated locally to become a window or a door.

A user-defined cursor

As a convenience in graphic input operations, the user can replace the cross-hair cursor with any picture segment. In the architectural application just discussed, the standard square could become the cursor, making it very convenient for positioning the square anywhere on the display.

Segments within segments

Another graphics convenience is the capability to include a copy of one or more segments within a segment. Consider, again, the architectural example. First, the host defines the exterior of the building as an individual picture segment and defines it as segment 1. The standard square displayed on-screen is defined as segment 2. Each time the architect positions and scales the square to create a door or window in the building, the host program commands the terminal to include a copy of segment 2 (as it appears on the screen) within segment 1. In this manner, segment 1 is progressively modified to contain the exterior of the building and all of its doors and windows. The host, then, with a single command to display segment 1, can redraw the exterior of the building with all of its openings.

Classes of segments

In some applications, it is desirable to modify related picture segments as a unit. This can be done by grouping several segments into a segment class. A segment may belong to one or more of a maximum of 64 classes.

To illustrate the utility of segment classes, consider an application that involves drawing a detailed block diagram of a complex instrument such as an oscilloscope. The block diagram could be constructed in modular form with separate modules for the trigger, timing, horizontal output, and so forth. The segments in each of the modules could be grouped into segment classes, one for each module. Using the host the user could then display or erase any module by sending a single command to the terminal.

A 4112 or 4114 equipped with the optional disk drive has the capacity to store locally-retained picture segments on the disk. The disk drive enables the host to load a segment from the disk into the terminal's memory directly. This is faster and less costly than retransmitting the data from the host.

The use of picture segments, segments within segments, local refresh and segment manipulation, and extensive local memory all serve to greatly reduce host communications traffic and increase the user's productivity.

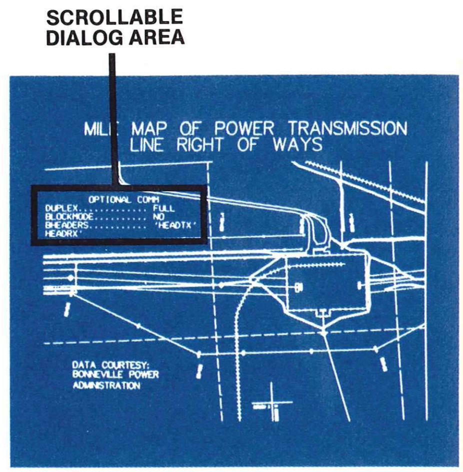


Fig. 2. Communications between the operator and the host computer are displayed in the dialog area. The size and location of the dialog area can be defined, to avoid interfering with displayed graphic information.

The dialog area

In addition to displaying picture information, a graphics terminal must provide a means for the operator at the keyboard to communicate with the host computer and, conversely, for the host to communicate with the operator. In some graphic terminals, the alphanumeric dialog between the operator and the host is sometimes written over the picture, necessitating redrawing of the picture. The 4112 and 4114 restrict the display of alphanumeric text to a defined dialog area (see figure 2). Communications between the host and the operator at the terminal are displayed in the dialog area; graphics information is displayed on the rest of the screen.

The dialog area on the 4112 and 4114 is scrollable. When filled with text, the top line is automatically moved up and out of view to make room for the next line of text at the bottom. Each line of alphanumeric text that is scrolled out of the dialog area is stored locally in RAM. This enables the operator to read previously displayed text by scrolling backwards with the keyboard thumbwheels.

The user can define the size of the memory buffer used to contain scrolled text, and can tailor the on-screen dialog area to the application by defining its size and position on the screen. The user can also choose to turn the dialog area on or off.

To provide for the scrolling capability, all text in the dialog area is displayed in refresh. In the 4112, the raster-scan tube pre-

A Direct-View Storage Tube With Color Refresh

The 4114 direct-view storage tube (DVST) terminal is given substantial refresh capability through the use of local random access memory. However, with flicker-free refresh it is sometimes difficult to distinguish between refreshed and stored images on the screen. The 4114 Color Enhanced Refresh option resolves that difficulty by displaying all refresh vectors in a second color. The color-refresh DVST displays stored information in the usual green color, while refreshed objects appear as a yellowish-orange hue easily distinguishable from the stored information.

Color refresh is accomplished by using a mixture of red and green phosphors for the DVST screen. In refresh mode, the writing beam excites both red and green phosphors, resulting in a yellowish-orange trace on the screen. The refreshed information, however, is displayed at a current density lower than that required to store a charge image.

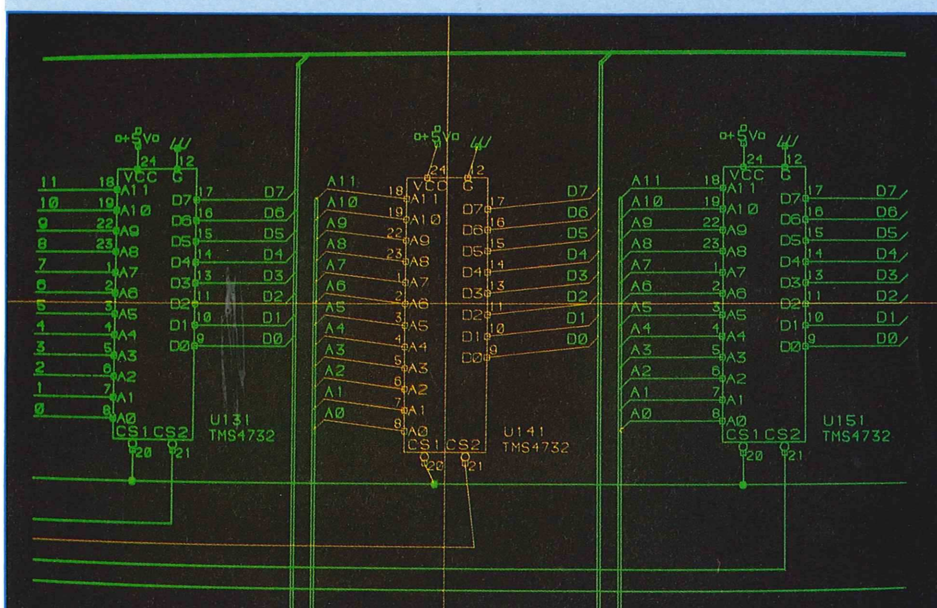


Fig. 1. A 4114 DVST display with color-enhanced refresh. The yellowish-orange hue of the refreshed information makes it easy to distinguish between stored and refreshed portions of the display.

To remain visible, the information must be continually refreshed.

In storage mode, the writing beam also excites both red and green phosphors causing a momentary yellowish-orange glow. In this case, the current density is high enough to store a charge image. After the writing beam draws the image, only the green phosphor continues to emit light. The red phosphor does not store because it requires a higher charge level to luminesce than does the green phosphor.

To achieve enough color shift to be easily discernible, the red phosphor must be 40 to 60 percent of the total by volume. However, this results in lowering the stored (green) luminance of the display. As luminance is also a function of power input to the screen, luminance can be restored by increasing this power. This is accomplished by processing the phosphor materials in such a way as to raise the nominal operating voltage level of the target, and changing the optics of the DVST funnel to increase the flood gun current density to the target. These changes result in a stored luminance 60 percent higher than that of conventional DVSTs.

Generally, an increase in the current density to the screen means a decrease in the life of the tube. In this instance, the use of rare-earth phosphors yields a 50 percent increase in tube life, even with the 60 percent increase in luminance.

An additional benefit of the new flood gun electron optics is improved hard copy capability. A primary factor in hard copy performance is the dispersion of flood-gun electrons in front of the tube target. The new design decreases the noise around the edges of the screen, resulting in consistently cleaner copies. ■

sents no limits to the size of the scrolling area; the 4114's DVST displays up to 300 characters in the dialog area.

Raster-scan graphics with the 4112

For applications that do not need the large screen and high resolution of the 4114, the raster-scan 4112 offers users some unique advantages: zoom and pan capability, multiple viewports, multiple-bit planes for gray-scale and overlays, a greater degree of operator interactivity, and lower cost.

The zoom and pan capabilities overcome the resolution limitations of the smaller CRT by allowing the user to isolate and magnify, on-screen, any section of the 4096 by 4096 point device coordinate space.

To understand how the zoom and pan features operate, it is necessary to understand the graphics concepts of window and viewport as they are used for the 4112. The window is any rectangular portion of the 4096 by 4096 point device coordinate space. The viewport is any rectangular portion of the display screen. The graphic contents of the window are mapped onto the viewport. The contents of the window determine the picture that will be displayed on the screen. The viewport determines the size and location, on-screen, of the displayed picture (see figure 3).

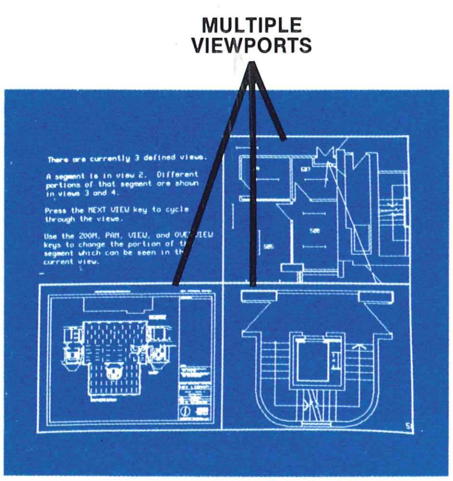


Fig. 3. Multiple viewports allow simultaneous display of an entire picture and enlarged views of selected portions of the picture.

Multiple viewports allow the user to display an entire picture on one portion of the screen, while detailed views of individual segments of the picture are displayed on other portions of the screen. The user can zoom and pan any viewport on-screen without affecting the images displayed on the other viewports. In addition, the user can specify which segments can be displayed in a viewport and which cannot. This feature allows the user to separately display pictures that might overlap in the device coordinate space, without the images overlapping on-screen.

Another powerful feature of the 4112 is the multi-bit plane capability that enables users to work with a maximum of three overlays, or up to eight shades of gray. Overlays are separately-addressable graphics surfaces. They can be compared to the transparent overlays commonly used in presentations made using an overhead projector. One of the more common applications for multi-bit planes is in the design of multi-layer printed circuit boards.

The gray-scale capability enables the user to "color" a picture with up to eight shades of gray to contrast various sections. Panels (polygonal areas of a picture) defined by the user can be filled with any of eight levels of gray scale, or with a user-defined pattern, or with one of 16 patterns available from the local intelligence of the 4112. A typical application would be the "coloring" of a map to mark differences in rainfall, temperature, population, and so forth.

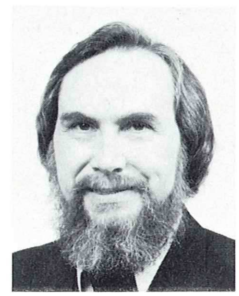
Summary

The new 4112 15-inch raster-scan terminal and 4114 19-inch DVST terminal provide computer graphics users a choice of display technology, more versatile graphics capability, increased productivity through the use of picture segments and fast repaint, and lower cost through reduction of host communications traffic.

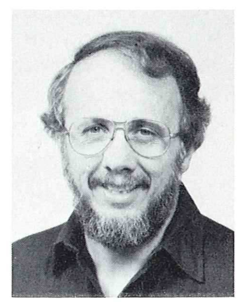
Compatibility with the 4010 Series of graphic terminals and between units of the 4110 Series allows users to expand their current 4010 software to incorporate the added capabilities of the 4112 and 4114, as the need arises.

Acknowledgements

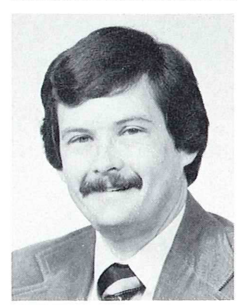
We would like to express our appreciation to all who contributed to the 4112 and 4114 projects. Special thanks are due Lee Boekelheide and Ned Thanhouser for their outstanding work on the software. ■



Dean Bailey is manager of graphic terminal development at Tek. During his ten years at Tek, he has been manager of the Host Software group, had system responsibility for a major revision of the 4081, and currently is managing the 4100 Series program. Dean has a B.S. in Math from Portland State University (1965). The theater occupies much of his leisure time. He currently is rehearsing for a role in the Shakespeare-in-the-Park production of "As You Like It." Dean also enjoys astrophotography and has a 14-inch portable telescope.

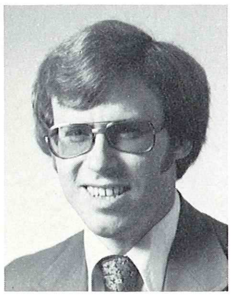


Jack Sterett, project leader for the 4114, has been with Tek since 1960. His design projects include the 422 and 323 portable scopes, 4010 and 4014 computer display terminals, and several other display products. Jack received his B.S.E.E. from Portland State University and is a Master's candidate at Oregon State University. For recreation Jack enjoys water and snow skiing, hunting, and fishing.



Dave Squire is project leader for the 4112 project. He started with Tek in 1969, as a member of the Industrial Engineering group. During a stint with the Systems Division he designed the sector card logic for the 3260 Semiconductor Test System. He is currently with the Information Display Division. Dave received his B.S.E.E. and M.S.E.E. from Oregon State University. He enjoys mountain climbing, jogging, and playing guitar in a small "bluegrass" band.

Software Innovations Increase Productivity of Desktop Computer Users



Bruce Rodgers, software marketing manager for the Graphic Computing Systems business unit, is responsible for new software product planning, development, and promotion. He received his B.A. from Central Washington University in 1971 and his M.B.A. from the University of Washington in 1974, joining Tek shortly thereafter.

In 1975, Tektronix introduced its first desktop graphic computing system — the 4051. This was followed by the even more versatile 4052 and the graphically interactive, large-screen 4054. Now, with the introduction of New Generation PLOT 50 Software, we greatly enhance the usefulness of our entire 4050 Series family.

Since the introduction of the 4051, there have been major changes in what 4050 Series users want. There is a tremendous demand for more applications-oriented software to enable the user who has little, or no, programming experience, to take advantage of the graphic power of the 4050 desktop family.

In 1975, users had more time to incorporate new computing techniques into their problem-solving activities. For most users, this is not so today. Interest centers on productivity, not in the novelty of learning new technology. For example, in the past, a design engineer often spent considerable time creating, adapting, and programming statistical routines on the computer because such routines were not available from the vendor. Today, new statistics packages must be very easy to learn and incorporate into an application. Statistical tasks are a bottleneck in the design activity and need to be completed in an expeditious and reliable manner. Although the products must be simple to learn, they must also contain sufficient power to help solve the user's application problems.

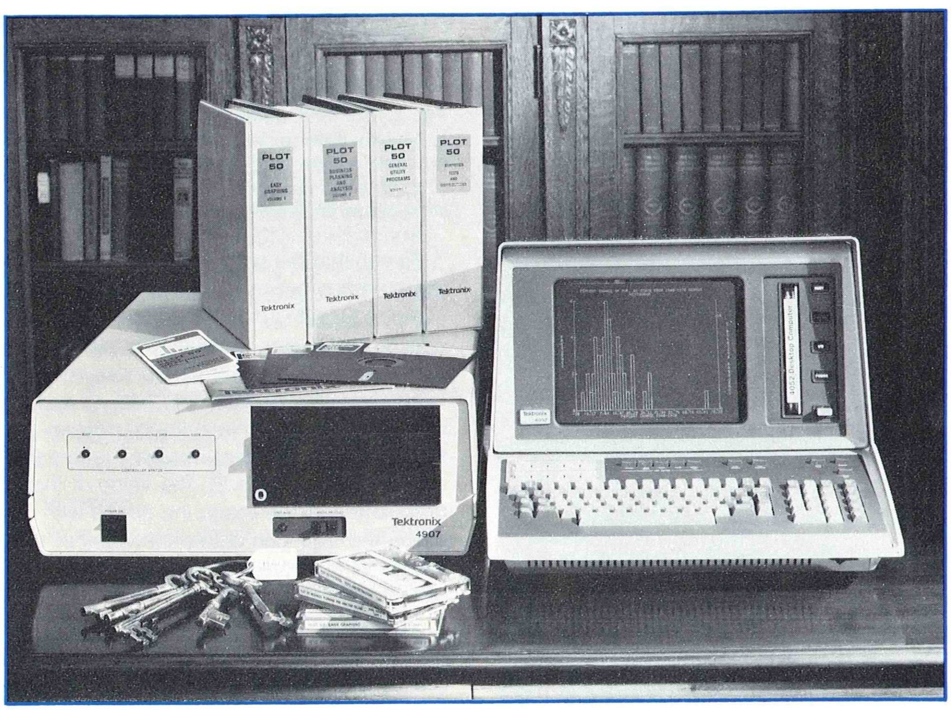


Fig. 1. The New Generation PLOT 50 Software is the key to easy use of the graphic power available in Tektronix 4050 Series desktop computers.

Design problems

A number of design problems had to be addressed early in the development of the New Generation PLOT 50 Software. Our market research indicated that few 4050 Series users' applications were static. Graphic computing system applications are diverse, and we had to learn more about application requirements in detail. Other factors to be considered included user familiarity with the hardware, user interface trade-offs between menus and commands, and differences in the learning curves of frequent-versus-infrequent users.

We decided that most 4050 Series users know far more about their applications than about their computing equipment. It was our task to provide the conventions of the applications to shorten the learning time for uses. Further, it was essential to provide a friendly interface with the software (and the hardware). Many vendors advertise friendly products; our challenge was to satisfy a wide range of user needs efficiently. In tangible terms, a first-time user should be able to operate the software within two to four hours after power-up, without having to study a user's manual.

Help and convenience for users

Most of the New Generation PLOT 50 Software packages include help files, tutorials, and menus. The tutorials quickly walk the user through product functions to rapidly achieve familiarity. The help files give details of program operation. For example, with the 4052D10 Document Preparation package, the user can display (with one function key) the menu of editing and formatting commands. Upon selecting a command, the user sees (on-screen) a description and an example of operation for that command. After obtaining the needed help, the user can easily return to the portion of the program where difficulty was encountered and then continue with the application from that point.

Most users prefer to first concentrate on solving their application problems and then spend secondary effort familiarizing themselves with the hardware and software to be used in that application. The New Generation PLOT 50 Software politely reminds users to check peripherals (and what to check for) to ensure proper operation.

In 4054D06 Picture Composition and 4052D07 Interactive Digitizing, the alignment of tablet menus and source documents is not important because easy and quick reference points are established which enable the software to make the necessary adjustments. For example, skewing errors are noted and automatically corrected so plotter output is not skewed relative to the X and Y axes. In each of the application packages there are many additional conveniences that help users to quickly become productive.

Application conventions

To better understand application conventions, we exchanged ideas with experts in several application areas. As an example, one exchange helped us to better understand what statistical techniques many users expect to employ when conducting small-sample statistical analysis. These "wants" then became the application conventions. We integrated these conventions into a simple-to-learn package that provides users with state-of-the-art techniques that key on graphics (through pattern recognition) to add meaning to users' data.

The value of graphics

Most of the New Generation PLOT 50 packages are built around the power of graphics. Conventional graphic techniques, such as scatter plots (as used in statistics) are included, as well as some unique new routines, such as box-and-whisker plots and normal curve overlays for viewing data. A brief review of some of these routines is helpful in understanding the power of graphic interpretation.

The statistics packages include routines for producing a box-and-whisker plot (see figure 2). The box represents the distribution of data about some observable median, while the edges of the box relate to quartiles, and the fences (whiskers) mark the range of most of the data in the distribution. The user has the option of examining one box at a time, or a number of boxes, to view variables within a group, or to look at a comparison of groups.

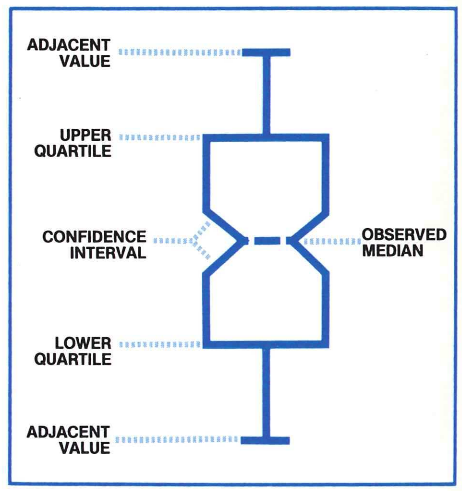


Fig. 2. Box and whisker plots enable the user to quickly determine if a statistical sample contains a high percentage of valid data. Use of such plots can save valuable time otherwise spent analyzing poorly-distributed data.

Recall that the purpose of the exercise in this statistics package is to analyze a small sample. Studying notches increases the user's productivity. Notched-box plots are used to note significant differences between two sets of data. Two sets of data whose notched intervals do not overlap are significantly different at roughly the five percent level (see figure 2). The value of this graphic technique lies in the speed with which the user can determine whether two groups of data are significantly different statistically.

Another of the exploratory plotting routines in the Statistics packages is the Normal Curve Overlay. In this case (see figure 3), a normal bell-shaped curve is inverted and plotted over a histogram representing

New Generation PLOT 50 Software Library

4050D02 Statistics Tests and Distributions *(Disk)*	Disk-based statistics for small sample and experimental analysis plus exploratory plotting routines
4050D03 Statistics Analysis of Variance *(Disk)*	ANOVA featuring one-, two-, and three-way classification techniques plus exploratory plotting routines
4050D04 Statistics Multiple Regressions *(Disk)*	Multiple, weighted, stepwise multiple, and polynomial regressions and exploratory plotting
4050D13 Statistics Library *(Disk)*	4050D02/4050D03/4050D04 (above) packaged as a library at discount
4054D06 Picture Composition *(Disk)*	Electronic "sketchpad" using graphic primitives (line, arc, circle, point, box, text) to create working drawings or pictures and sub-pictures using 4050 Option 30 Dynamic Graphics
4052 Interactive Digitizing *(Disk)*	For production (bulk) digitizing tasks in cartographic, design engineering, and strip chart analysis applications including editing and basic calculations
4052D10 Document Preparation *(Disk)*	Powerful command-driven package for formatting, editing, and preparation of multi-page documents
4050D11 *(Disk)* **4050A17** *(Tape)* **MicroPert 2 - Project Management**	State-of-the-art desktop offering of PERT and CPM techniques including rich set of resource management facilities, graphic charting, and reporting options
4050A16 Presentation Aids *(Tape)*	For the creation of overhead presentation materials based on template construction including bar charting, line graphs, pie charts, and text

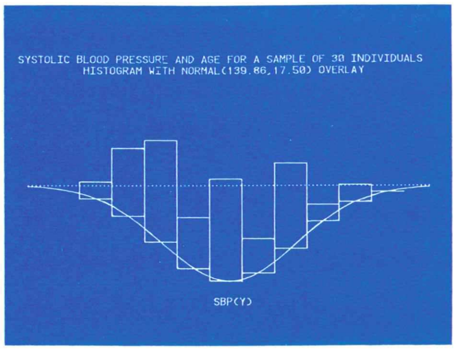


Fig. 3. The Normal Curve Overlay plotting routine enables even a casual statistics user to quickly spot deviations from an arbitrarily defined zero line.

the distribution of the data in the sample. The dotted line represents an arbitrarily defined zero-line as a reference point, so that even a casual statistics user can quickly see deviations from the zero-line. These graphic techniques are included in our software because they are easy to learn and provide powerful insight into the data being analyzed.

There are several of these plotting techniques in most of the New Generation PLOT 50 Software packages. They are available by answering only a few questions, by selecting an item from a menu, or by selecting the appropriate key on the 4050 Series device. In other words, no programming is needed. Access to the power of these graphic techniques is simple and quick.

Commonality

Each of the three Statistics packages comes with a Function Key Overlay that fits on the keyboard of the 4050 Series computers. The same functions are located on the same keys in every package. For example, Master Menu is key 10, Data Entry is key 1, Print and Plot are keys 7 and 8, respectively. This is not a major product feature but indicates the care employed in designing the products so users will find them easy to learn and operate correctly.

Fatal errors

Previous software offerings did not include provisions to protect users who lacked hardware familiarity, from destroying programs. For example, if you tried to plot a set of data by selecting a histogram function, with no data present in memory, the program usually crashed and you had to restart. Today, the operating system checks to make sure data is present before attempting to create the graph. If no data exists, polite instructions appear on the screen to guide the user to the next step to keep the program going. This type of design provides not only friendly software but forgiving software.

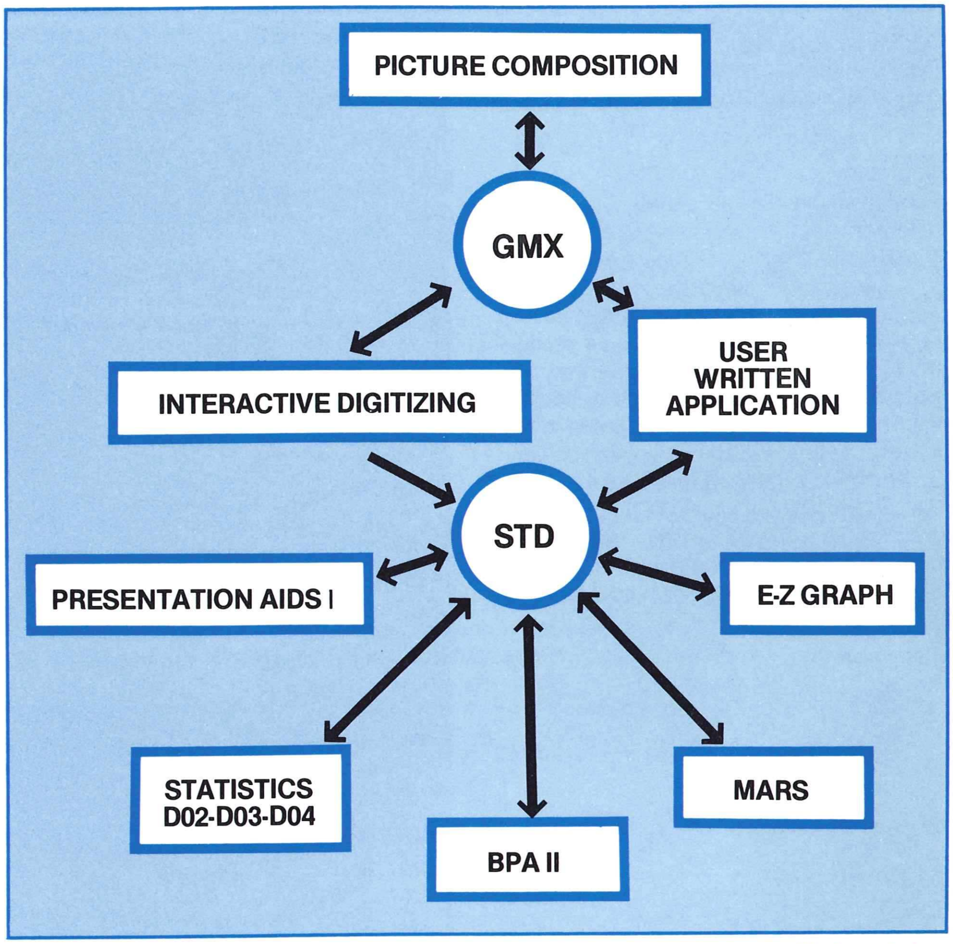


Fig. 4. Data exchange formats developed for the PLOT 50 software products provide for substantial gains in user productivity. Standard File Format (SFF) files numeric data that can be accessed directly by other PLOT 50 programs having SFF capability. Graphic Model Exchange (GMX) provides a similar capability for graphic information.

PLOT 50 Software exchange formats

Two data-base-oriented standard filing techniques were developed by Tektronix for these (and future) software products. The Standard File Format (SFF) is a technique for storing data in such a manner that the data can be accessed by other PLOT 50 programs having SFF capability. (We have found few users who enjoy worrying about marking files and fretting over file sizes.) When data entry is complete, the user need activate only one key or function for SFF construction to occur automatically. File creation is automatic and access easy and logical. First, the software prompts users to file data by name (not number) because names we create are easy to associate and remember. Second, the files are called by name, and if you cannot remember the names of all of your files, directories allow you to recall the files one at a time or to list all of them.

The Graphic Model Exchange (GMX) can be considered the graphic complement of SFF. In SFF, the user stores numeric information. In GMX, the user stores graphic or pictorial information. This means that a graph created by one software package can be called by name by another software package (with GMX capability) and another operation be performed on that same file (see figure 4).

What SFF and GMX mean to the user are tremendous gains in efficiency because the data need be entered in the computer only one time (as opposed to entering the data for each different program).

Summary

For people who are not skilled computer programmers, the New Generation PLOT 50 Software products provide the capability to access the graphic power of the desktop 4050 Series and apply it quickly to their problem-solving tasks. The need for productivity gains takes precedence over the novelty of learning new software or hardware. For those who have the desire to use it, the programming and computing power of the 4050 Series is always available. These New Generation PLOT 50 Software products offer a wide range of users the opportunity to unlock the power of the 4050 Series and use it to their own advantage. ■

Three New Portable Oscilloscopes Designed for Field Service Use

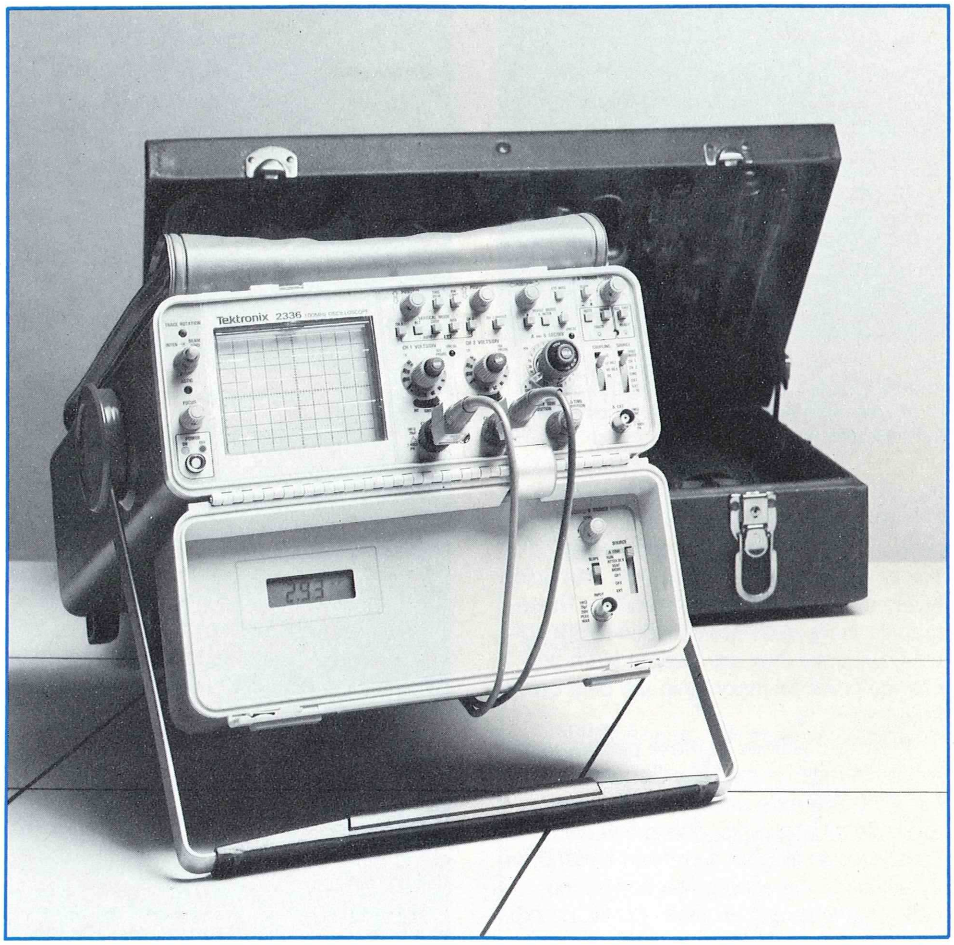


Figure 1. The Tektronix 2336 is one of three models available in the new 2300 Series of oscilloscopes. The 2336 features 100 MHz, dual trace, and delaying sweep operation, with delta-time measurement displayed on the 4-digit liquid crystal readout located in the cover. Use of the cover to contain auxiliary functions keeps the main front panel uncluttered for easy operation.

The concept of portability has changed greatly over the years. Tektronix' first oscilloscope, back in 1947, was portable. It weighed *only* 55 pounds, and had a handle. You could pick it up and carry it — but not very far. It was portable, but it was designed primarily for laboratory use.

Today, many oscilloscopes designed primarily for portability are purchased for laboratory use, and their design is optimized to accommodate both functions.

The new Tektronix 2300 Series Oscilloscopes are designed expressly for portability — and more precisely — for field service. Small, rugged, and reliable — they are built to work in adverse environments.

The 2300 Series includes three instruments: the 2335, a dual-trace, 100-MHz bandwidth, delaying sweep oscilloscope; the 2336, identical to the 2335, with a B-trigger function and delta-time measurement capability; and the 2337, with all of the features of the 2336, plus a general purpose digital multimeter. Each of the instruments weighs less than nineteen pounds and measures just 5 by 12 by 17 inches.

Concentrating on portability

Because field service requirements were the prime consideration, the designers of the 2300 Series concentrated on reducing size and optimizing ruggedness and reliability, rather than introducing new features. There were, of course, other important factors to consider, such as operating ease, display size and resolution, and serviceability, to name just a few.

The dimensions of the cathode ray tube (CRT) usually dictate the minimum length and height of an oscilloscope package.

Because of its mass, size, and complex structure, the CRT is also the component most vulnerable to physical shock. Thus, work on the 2300 Series began with redesign of our smallest, 100-MHz, high-performance CRT. The result is a CRT 30 percent shorter than its predecessor, having a 6.4 by 8.0 centimeter display area, with trace intensity and spot size optimized for a bright, sharp, high-quality trace.

Unique CRT mounting improves ruggedness

In designing a very portable oscilloscope, CRT breakage is a vital concern. Conventionally-mounted CRTs are supported at both ends — a technique that has proven reliable but which can result in high stress being applied to the CRT if the instrument is subjected to a severe drop.

The 2300 Series use a cantilever mounting system that enables the CRT to withstand shocks three to four times greater than conventionally-mounted tubes can handle. The new mounting system consists of a single mounting that fastens the front of the CRT to the oscilloscope's front subpanel, using just four screws (see figure 2). A key element in the mounting system is the Tek-manufactured ceramic tube, which makes it possible to tighten the mounting screws directly into the CRT's funnel.

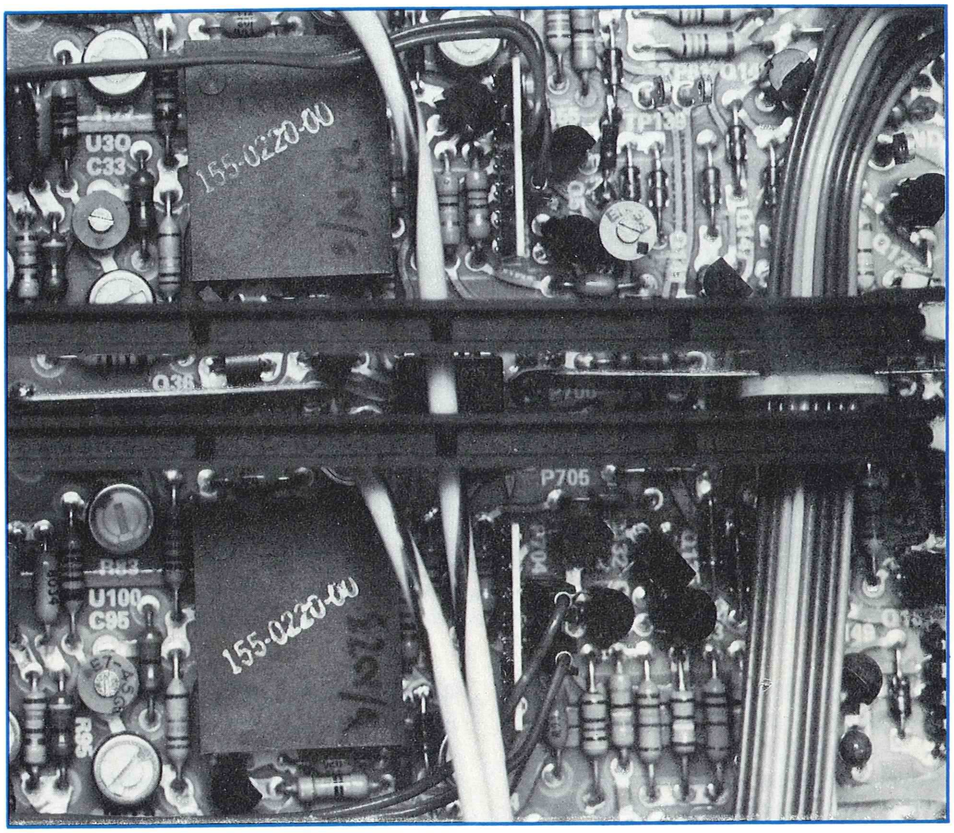


Figure 3. The hybrid preamplifier circuit used in all of the 2300 Series provides many of the advantages of an integrated circuit but required considerably less development time.

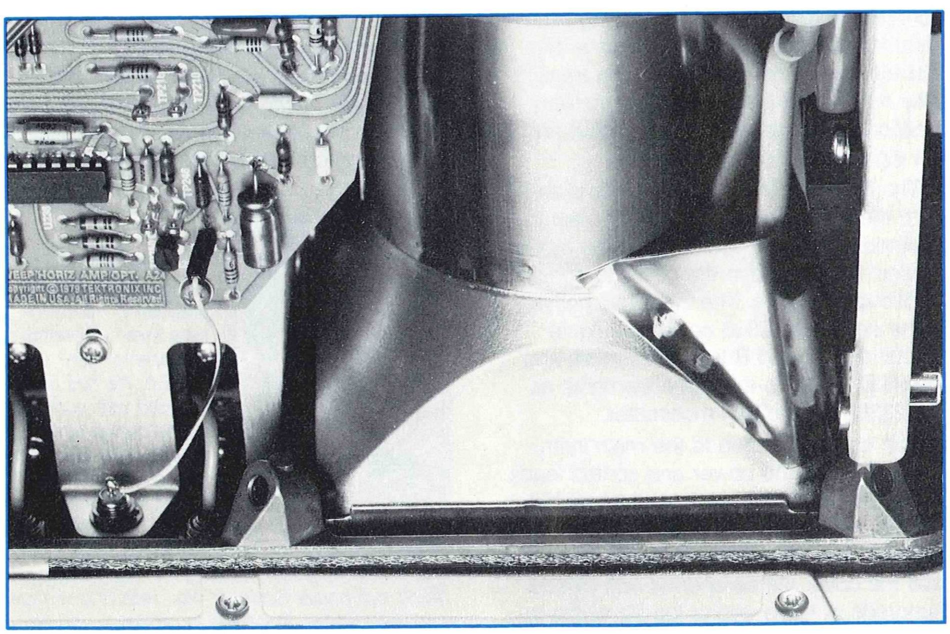


Figure 2. Unique mounting system which supports the CRT only at the front panel reduces probability of damage to the CRT should the instrument be subjected to a severe drop.

Circuit boards add support

One of the challenges in portable-oscilloscope design is to pack in all the performance needed, yet make the instrument easy to service. In the 2300 Series, this challenge was met by having the circuit boards all face outward, forming a box-like structure around the CRT. This arrangement provides excellent access for servicing. In addition, the circuit boards and their mountings serve as internal structural support for the instrument's chassis. Irregular-shaped boards were used where necessary, to utilize the available space.

Circuit-board real estate was conserved through judicious use of integrated circuits and thick-film hybrid circuits. The preamplifier circuit (figure 3) is a hybrid consisting of components silk-screened onto a ceramic substrate, with transistors soldered directly onto the substrate. This technique yields much of the advantage of an integrated circuit, with a shorter development time than that required for custom ICs.

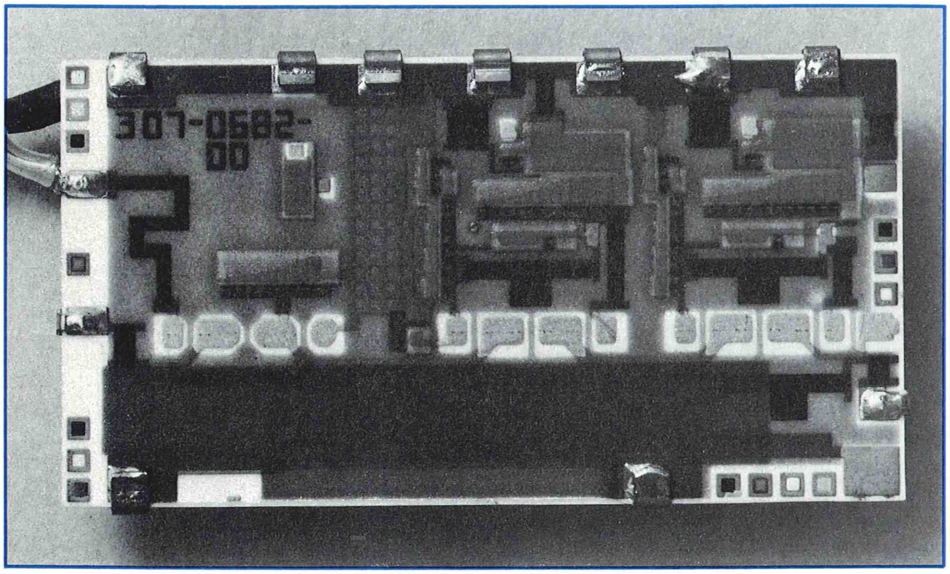


Figure 4. Two-stage hybrid attenuator uses laser-trimmed resistance and capacitance values to create a compact, preadjusted attenuator that requires no adjustment after installation in the instrument.

A laser-trimmed attenuator

The input attenuators in the 2300 Series are also unique. Smaller than conventional designs, the attenuators are compensated by laser trimming prior to installation in the instrument and never need adjustment. In contrast, the typical attenuator has many adjustments and must be adjusted after installation in the instrument. The new design reduces instrument calibration time and is more reliable than its predecessors.

Deep-drawn cabinet provides protection

The single-piece, deep-drawn cabinet housing the 2300 Series is a significant achievement. Pure aluminum could easily be formed to the required depth but was not strong enough. Working closely with experts in deep drawing aluminum, Tek engineers helped develop one of the deepest drawn cans of 6061 T6 alloy ever manufactured. This accomplishment was essential in making the 2300 Series lightweight and strong.

The cabinet also plays an important role in realizing the design goal for electromagnetic interference (EMI). Portables often operate within the strong radio-frequency fields of radio and television transmitters, industrial machinery, and so forth. Close attention was given to EMI at every step of the instrument design, resulting in an EMI specification of 10 volts per meter (radiated susceptibility).

A new front-panel concept

In addition to the CRT, another factor that determines instrument size is the front-panel space needed for the controls. Controls can be made small and closely spaced but the instrument will be difficult to operate. The 2300 Series designers use a new approach that effectively doubles the front-panel space without increasing instrument size. Portables need a cover to protect the front-panel controls during transit. Why not use the cover to house auxiliary functions, such as delta time readout and the digital multimeter?

The cover for the 2300 Series is drawn from the same tough alloy as the main instrument cabinet. Depending on the model, a panel is mounted in the cover to contain additional functions. The 2335 has nothing in the cover; the 2336 contains a liquid crystal display and B trigger controls; and the 2337 contains the same elements as the 2336 plus a digital multimeter.

The cover is hinged to the main instrument cabinet, and power and control leads are coupled to the cover panel through a flexible, flat cable. A beryllium-copper shield provides EMI protection. One can expect that the cover will be opened and closed hundreds of times during the life of the instrument. To verify reliability, the cable was tested up to 100,000 openings and closings without an electrical failure.

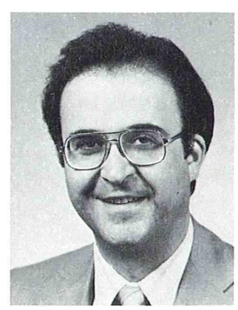
Considerable thought was given to both logical organization and spacing of the front-panel controls to ensure straightforward, easy operation. All of the positioning controls are in a row at the top of the panel, mode switches are just below, and the step attenuators and time per division controls are lined up in the center. This arrangement makes the oscilloscope easy to use, even by inexperienced technicians.

A new target for innovation

Usually, in designing a new oscilloscope, the bulk of the effort is applied to developing new circuitry. In the 2300 Series, the focus has been on applying technology and innovation, not so much to expand performance specifications, but to increase portability, reliability, ruggedness, and manufacturability, while maintaining a popular set of features (100 MHz, dual trace, delaying sweep, etc.). The 2300 Series represent a substantial improvement in field service instrumentation.

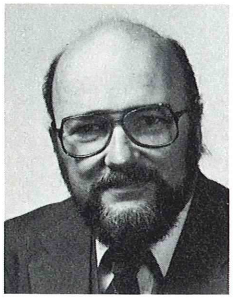
Acknowledgements

Many people were involved in the design of the 2300 Series. A special note of thanks goes to Mike Kyle, project leader for mechanical design, and to Dave Hargis and Earl Orme who worked with him. Special thanks to John Taggart, project leader for electrical design, and Dave Allen, Gene Cowan, Jim Godwin, Carl Matson, and Ted Nelson, all electrical designers for the project. Dennis Bratz provided valuable insight into manufacturing techniques and performed production evaluation. My thanks also to others who contributed to the project. ■

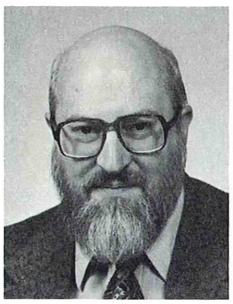


Peter Zietzke joined Tek in 1974 following graduation from Montana State University at Bozeman with a B.S.E.E. He has been involved with portable scope design since coming with Tek, working on two of the 200 Series Miniscopes, as project manager for the 442, and currently as project manager for the 2300 Series. Pete's outside activities include building miniature boats, trains, doll house furniture, etc., restoring vintage cars (he has two Packards in process), and fiddling with new circuits.

A High Resolution Color Picture Monitor for Television and Laboratory Use



Joe Hallett is Marketing Product Manager for television picture monitors. He joined Tek in January 1980 from GTE Sylvania, where he worked on development of electronic displays and equipment for cathode ray tube production. Joe received his B.S.E.E. in 1955 from Northeastern University in Boston. In his leisure hours Joe enjoys skiing, photography, travel, and amateur radio.



John Horn is Project Manager for the 690SR. He has been with the television products group since coming to Tek in 1960. John has contributed to the design of many products including the 528 Waveform Monitor, 650 and 670 Series Picture Monitors, and the 1420 Series Vectorscopes. John enjoys the outdoors — camping, hiking, and sailing.

Television stations, production studios, development laboratories, and quality control facilities need precise color picture monitors to accurately display every signal detail, whether generated by a conventional color television camera or by a computer-based imaging system.

There are two particularly critical places in the typical television program production facility where a precise color monitor is needed. One is the point at which the final television product is displayed to the executive responsible for final approval of the product. The monitor must accurately portray the program material complete with any compromises or defects that may be present. A subjective judgment will be made to determine whether the final product is acceptable.

A second critical viewing position is at camera-control positions where the quality of the original signal is established. Registration of the three primary colors at the camera is a critical task; the highest-resolution monochrome monitors are often used in making the initial setup. During production, an accurate color display allows the operator to observe slight adjustment errors and make corrections while the production continues. Only a monitor with excellent convergence can be used for this task.

In these, and other applications, the monitor is the quality standard and it must be extremely stable so that it is not suspect when picture defects are noted.

The Tektronix 690SR Color Picture Monitor is designed for just such critical viewing applications. With the appropriate plug-in interface module, the 690SR can display pictures originating in either a television system or a digital image buffer.

Wide-range deflection circuits produce horizontal scan rates from 15 kHz to 37.5 kHz. The 690SR accommodates conventional interlaced raster display formats including the standard 525-line and 625-line television systems and can operate at more than 1024 lines per frame for computer applications. Convergence circuits track picture size, aspect ratio and scan rate to allow operation in special applications, with only minor readjustment.

A high quality CRT

The key element in a high-resolution monitor is a high-resolution cathode ray tube (CRT). The 690SR uses a delta-gun, dot-shadowmask CRT with an extremely fine shadowmask structure; triad spacing is 0.31 millimeter as compared with 0.6 to 0.8 millimeter for home television picture tubes. There are approximately 1800 phosphor dots vertically and 1400 horizontally for each color, in the CRT screen. Efficient phosphors permit the use of relatively high brightness levels without sacrificing picture quality.

Inherent in current CRT technology is a tradeoff between fine screen structure and screen uniformity. For those applications where the operator must be close to the display screen, the fine screen is less objectionable than coarser screens. However, for greater viewing distances a medium resolution (0.4 to 0.6 millimeter) CRT provides better screen uniformity and adequate fineness. The medium resolution CRT is offered as an option for the 690SR.

Easy convergence adjustment

Complementing the high-resolution picture tube are high-stability convergence circuits. The specified convergence accuracy is better than 0.5 mm; this is the maximum separation permitted between any pair of red, green, or blue picture elements (center to center) and corresponds to less than 0.1 percent of picture height anywhere on the screen.

The convergence circuit adjustments are precision potentiometers with large, easy to set knobs located in a lockable front drawer where they are easily accessible to qualified personnel. Color coded graphics adjacent to each control provide a convenient reminder of each control function. The convergence signals are matrixed in such a way that beam motions are approximately up-down or left-right in response to control movements. This greatly simplifies convergence setup.

A solid white

One of the major concerns in a television program production is that the color temperature of "white" be set accurately and not drift. Drifting white balance causes unnatural colors to appear, which is particularly offensive to everyone if skin tones, snow, or other light-colored areas are involved. It is particularily objectionable to a sponsor to see the color of the product distorted in a commercial production.

To reduce the need for white-balance adjustment, the 690SR employs beam-current feedback to offset changes in the CRT cutoff characteristics as the tube ages. Carefully designed video circuits ensure that tracking errors (differences in video gain between red, blue, and green channels) are held to less than two percent. While it is not feasible today to eliminate white-balance adjustments entirely, the 690SR reduces these adjustments to the level of routine maintenance. Such stability ensures that if a problem is visible during critical viewing of a television production, it is not likely to be in the picture monitor.

Modularity for configurability

Modular construction makes it easy to configure the 690SR for different applications. The plug-in interface module processes the video input signals for application to the mainframe.

In the typical display of computer-generated pictures, a simple RGB interface can be used because no color decoding is required. In this case, the red, green, and blue signals are buffered and conditioned to drive the 690SR mainframe inputs. Sync separation is provided to obtain the horizontal and vertical triggers needed by the mainframe scan control circuits.

The NTSC television signal decoder is the first interface available for the 690SR. The NTSC decoder contains sync separation, color decoder, horizontal AFC, and other functions necessary for operation of

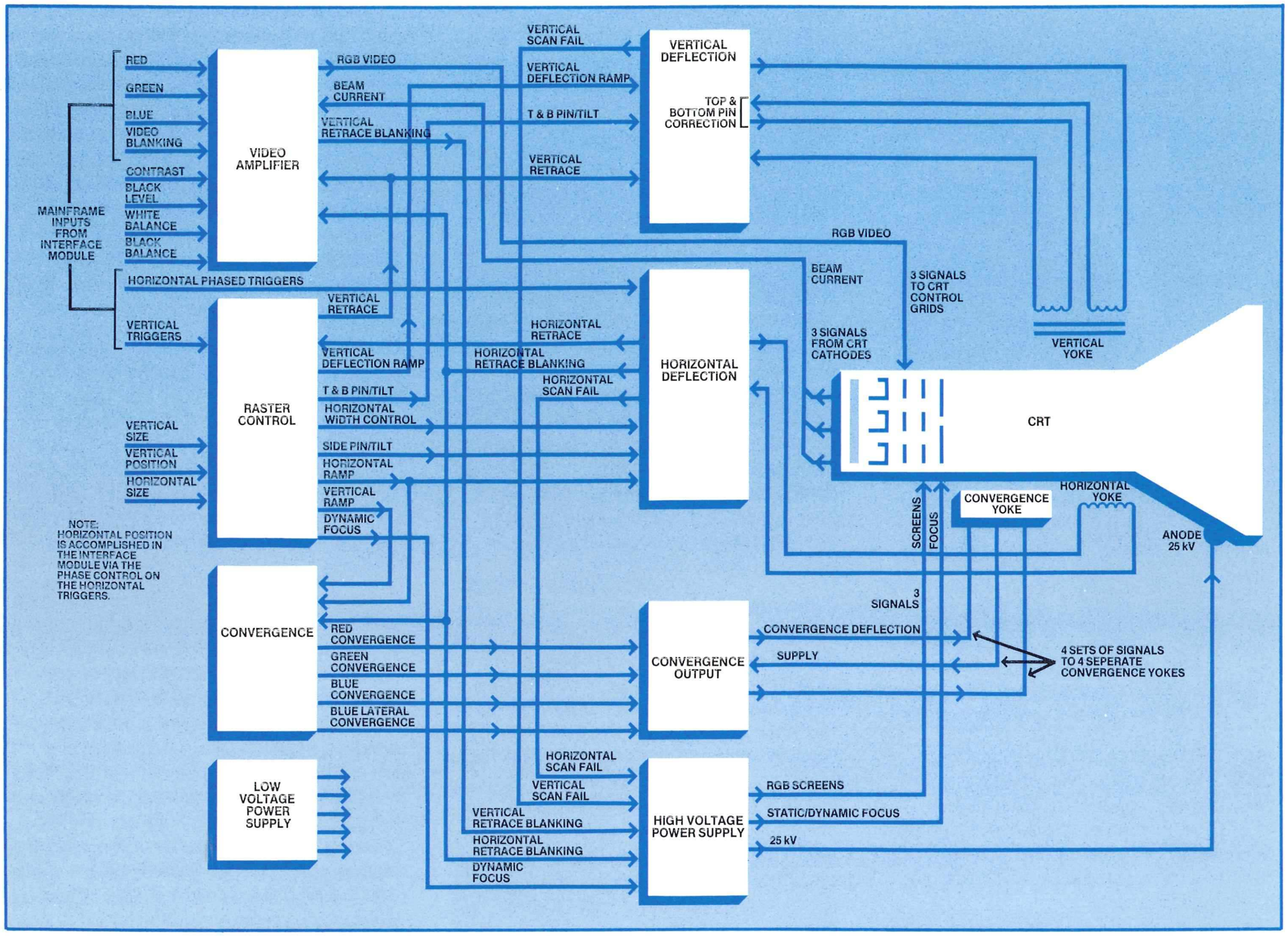


Fig. 1. Simplified block diagram of the 690SR. Convergence and high voltage circuitry operate independently of the horizontal and vertical deflection circuitry to facilitate operation at different scan rates and scan sizes.

the 690SR as a television picture monitor. The interface module also includes front panel controls unique to its function.

A simplified block diagram of the 690SR is shown in figure 1. The video amplifier module contains identical amplifiers for the red, blue, and green channels. Each has controls for low-level and high-level white balancing. A feedback loop in each channel senses CRT cathode current once per displayed field. This signal maintains the black-level current at a preset level, thus minimizing changes in color balance caused by CRT aging.

The video response is matched to the high-resolution CRT to minimize moire patterns caused by out-of-band signals beating with the sampling frequencies produced when the CRT beam scans the individual phosphor dots.

Two factors — greater information density and decreased scan times — require a video bandwidth about five times greater than that of conventional television systems. The CRT in the 690SR can display about 1000 picture elements (pixels) per scan line as contrasted with the 400 to 500 pixels per scan line of conventional television. (This resolution is not the same as the number of phosphor dots along a horizontal line, as the CRT beam spot size is larger and determines resolution.) In addition, the line-scan time can be shortened from the conventional 52 microseconds to as little as 20 microseconds, to achieve a comparable improvement in vertical information density without flicker. The video amplifier has a Gaussian response with a risetime or falltime of about 14 microseconds, which corresponds to a minus 3dB point of 24 MHz. The transient response is essentially the same for large or small signals. The output stages of these amplifiers utilize dual MOS power FETs in a single-ended class A configuration.

In the 690SR, wide-bandwidth video response and fast scan rates combine with the beam profile and fine-pitch phosphor pattern of the CRT to provide a display system suitable for both conventional television and high-definition television and graphics.

The raster-control module

The 690SR operates over a wide range of vertical and horizontal scan rates. The key to wide-range operation is the raster-control module. This module translates the interval between successive horizontal and vertical triggers, and horizontal and vertical size information, into signals that represent linear displacement across the CRT screen. From this positional information, all scan and correction signals are developed. This unique architecture minimizes readjustments for scan size, linearity, convergence, and dynamic focus when scan rates are changed.

The conversion from time to position across the CRT screen is accomplished using horizontal and vertical constant-amplitude ramp generators. The ramp generators are unique in that ramp amplitude is independent of control signal frequency. Further, the slope of the ramp is changed without changing the integrator timing components.

The basic ramp generator circuit (figure 2) consists of a comparator, Miller integrator, switching transistor, and peak detector. A control signal (the horizontal retrace blanking pulse) turns on the switching transistor, thereby discharging the integrator capacitor. The high period of the control pulse corresponds to the horizontal retrace time. When the control pulse goes low, the transistor turns off and the Miller integrator produces a linear ramp whose amplitude is determined by the reference voltage setting. The slope of the ramp is determined by the values of R_t and C_t and the output voltage of the comparator. The peak detector detects the peak voltage of the output ramp. If the peak voltage is less than the reference voltage, the output voltage from the comparator decreases, increasing the current flowing through the Miller integrator.

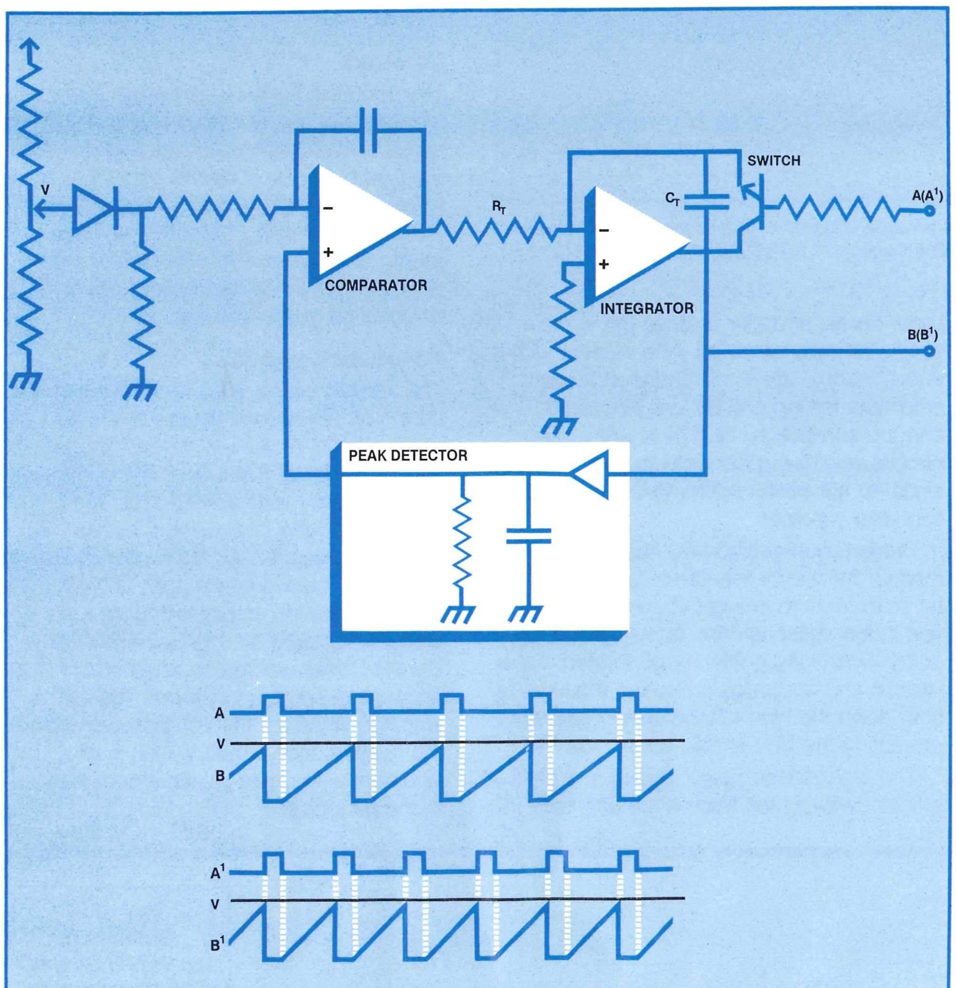


Fig. 2. Simplified schematic of ramp generator with constant-amplitude output independent of control signal frequency. Output of peak detector provides feedback signal to adjust Miller integrator current as needed to maintain constant output amplitude.

The slope of the ramp increases to restore the peak of the ramp to the level of the reference voltage. Thus, the amplitude of the ramp is determined by the reference voltage, independent of the control pulse frequency.

The raster control module also provides pincushion and tilt correction signals to the horizontal and vertical deflection modules. A dynamic focus signal, sent to the high voltage supply, maintains a sharp focus over the entire screen. The horizontal and vertical ramp signals are sent to the convergence module to provide beam-position information.

The convergence circuits

The convergence circuitry uses low-power active techniques with quality potentiometers and other components to ensure stability and reliability. The convergence module, located in the front drawer, provides the precision correction waveforms, and the convergence output module provides the driving signals for coils in the convergence yoke.

The convergence circuitry drives two sets of coils — one set in the main convergence yoke, and a second set in an auxiliary yoke. In the main convergence yoke, the red and green coils control both the horizontal and vertical positions of their respective beams. The blue coil, however, is positioned such that it controls only the vertical position of the blue beam. Horizontal positioning of the blue beam is controlled by the blue-lateral signal, which drives the auxiliary yoke. The coils in this yoke are oriented such that the magnetic field created provides horizontal positioning of the blue beam but has little affect on the red and green beams (figure 4).

Four convergence-correction signals are generated to drive the convergence coils: red convergence, green convergence, blue convergence, and blue-lateral convergence. Each of these four signals is a combination of convegence-correction signals. The primary correction signals consist of essentially half parabolas, which, when their amplitude and polarity are adjusted, change the convergence linearity of a given area of the display. The secondary convergence-correction signals consist of "B" shaped and "S" shaped waveforms that affect the symmetry top-to-bottom and left-to-right.

The convergence matrix is made up of divider networks that allow various magnitudes of the signals to be picked off to

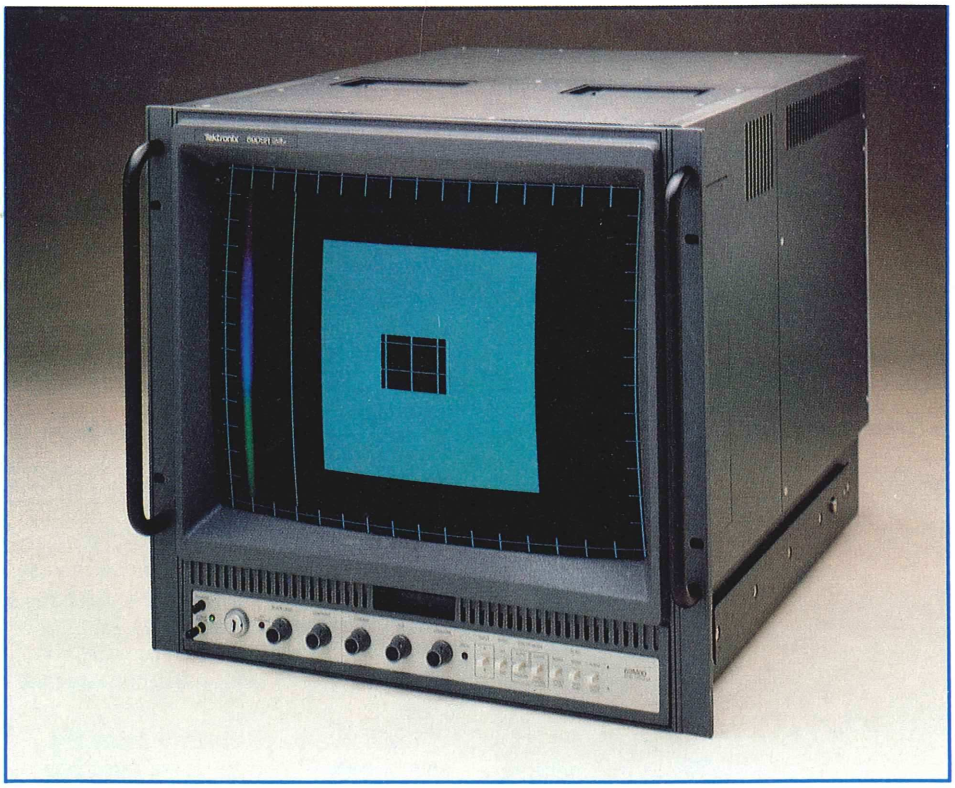


Fig. 3. The 690SR Color Picture Monitor is a high-resolution monitor suitable for both color television production and digital imaging applications. The Option 01 NTSC decoder interface is in use in this photo.

drive specific convergence coils. These individual signals are then summed to create the four convergence-correction signals. The signals are matrixed in such a way that beam motions are generally up-down and left-right in response to control movements, thus greatly simplifying convergence setup.

The deflection amplifiers

The horizontal deflection module contains resonant-scan circuits for driving the horizontal deflection yoke windings. Unlike many display deflection circuits, the 690SR horizontal deflection circuits operate independent of the high-voltage supply, thus avoiding compromises in deflection performance and making the high voltage (and picture size) independent of scan rate.

The vertical deflection module contains a linear power amplifier to drive the vertical deflection yoke windings. Also located within this module are the linearity correction amplifiers for top and bottom pincushion and top and bottom tilt. These are active circuits whose outputs provide a correction signal to the center of the vertical deflection yoke windings.

Protective circuitry in the raster-control module limits both the vertical and horizontal scan rates to prevent excessive dissipation in the deflection and convergence circuitry. Scan-fail signals are generated in the vertical and horizontal deflection modules to shut down the high-voltage supply, thereby protecting the CRT should either scan fail.

The high-voltage power supply is a high-efficiency switching type, which provides 25 kV to the CRT, along with other CRT operating potentials. Output ripple is synchronized to the horizontal frequency. The dc (static) focus output is adjustable independent of the anode voltage.

A rugged design

Another unusual feature of the 690SR is its physical design. The 690SR is designed to withstand severe shock and vibration, and relies mainly upon convection cooling to maintain conservative operating conditions for its electronic components. The structure and cooling method are interrelated, with the structural supports also serving as thermal guides to direct convection heat flow.

The 690SR is listed under Underwriters Standards 478 and 1244 (Pending, June 1981), certified per Canadian Standards Association bulletin 556B, and complies with European safety standards IEC 348 and IEC 435.

Summary

The 690SR is a new type of high performance color monitor for professional use in television production facilities and development laboratories. It has features which make it adaptable to both conventional television and digital computer environments, and has built-in potential for expansion to serve these rapidly merging technologies for years to come.

Acknowledgements

The authors would like to acknowledge the efforts of all who contributed to the success of the 690SR project. Wayne Olmstead was project leader and designed the deflection modules and raster control system; Gary Andrews did the interconnect system and the NTSC decoder; Archie Barter designed the Z-axis, low voltage supply, and did early work on the high voltage circuitry; Dan Baker completed the high voltage supply; Dan Teichmer worked on an interface to be announced soon; and Clayton Wahlquist, who has since left the company, designed the convergence circuitry. Our thanks also to others who made valuable contributions to the project. ■

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