The 4663 — Large Plotter Capability with Small Plotter Convenience

Parameter Entry Device Simplifies Plotter Set-up and Servicing

Updating the Industry-Standard 100 MHz Portable Oscilloscope

New Products

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Tekscope

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The 4663 — Large Plotter Capability with Small Plotter Convenience

The 4663 is a C-size interactive digital plotter that features easy set-up, plotting on a variety of media, and fast dual-pen plotting. Extensive firmware provides unusual versatility even with a host computer of limited capability.

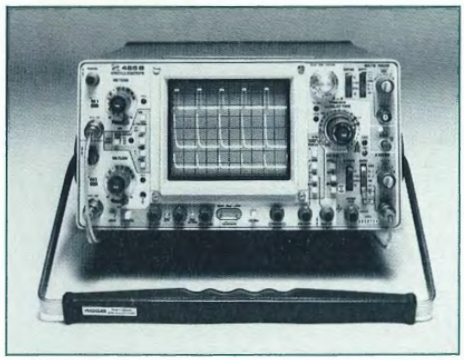
Tekscope is a bimonthly publication of Tektronix, Inc. In it you will find articles covering the entire scope of Tektronix' products. Technical articles discuss what's new in circuit and component design, measurement capability, and measurement technique. A new products section gives a brief description of products recently introduced and provides an opportunity to request further information.

Parameter Entry Device Simplifies Plotter Set-up and Servicing

The parameter entry device replaces the usual profusion of rear-panel switches and jumpers, with just eight LED-lit pushbutton switches. The plotter can be put in a preselected operating configuration by pressing a single pushbutton switch.

Updating the Industry-Standard 100 MHz Portable Oscilloscope

The new 465B updates the industry standard with new display capability, faster sweeps, and even better reliability. Front-panel layout remains essentially the same as the 465 to eliminate the need for operator retraining.

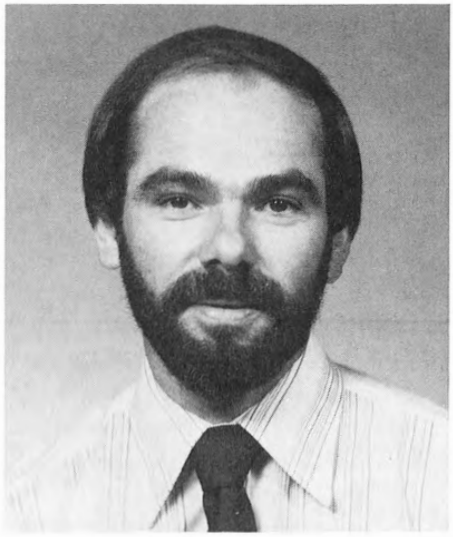


Cover: Setting up the 4663 Interactive Digital Plotter is greatly simplified through the use of the parameter entry device pictured here. The parameter entry card provides for step-by-step selection of the desired operating parameters.

The 4663 — Large Plotter Capability with Small Plotter Convenience

Douglas Bingham

Doug worked as a summer student at Tek while pursuing his B.S.E.E. at the University of Washington. He received his B.S.E.E. in 1965 and his M.S.E.E. in 1967. Following a stint with the military, Doug returned to Tek full time. He has worked on various microprocessor investigation projects, with his latest assignment as Firmware Project Engineer for the 4662 and 4663 Digital Plotters.



Guenther Wimmer

Guenther came to Tektronix in 1971 with an extensive background in the design of computerized numerical controls and precision large-scale photo plotters. He has been involved with Tek's digital plotter program since its beginning, serving as Project Engineer for the 4661, 4662, and 4663.

Most plotters are either too small or too large, too limited or too sophisticated, for many of today's applications.

The new TEKTRONIX 4663 C-size digital plotter is designed for those jobs requiring the versatility of a large plotter and the convenience and operating ease of a small plotter.

In applications like printed circuit board layout, numerical control, mapping, drafting, and report generation, most jobs fit easily on the 4663's 17 x 23.5 in plotting area.

The 4663 provides a choice of plotting media. Any media size up to U.S. C-size or European A2-size (420 x 594 mm) paper can be accommodated by the electrostatic hold-down platen. For automated production of multiple plots, an optional programmable paper advance for roll stock is available. Plotting can also be done on acetate film for preparing transparencies, etc.

The media choice is complemented by a choice of fiber tip, ball point, and wet ink multi-color pens. The 4663 features a dual pen carriage for fast two-color plotting. Pen selection is programmable, and optimum pen velocity and pen force for each pen station can be assigned by the operator.

Versatility with operating ease.

Versatility is often synonomous with complexity — but not in the 4663. A unique parameter entry device replaces the profusion of switches, jumper straps, and other rear panel arrangements common to most plotters, terminals, and similar peripheral equipment.

Some dozen system parameters and a like number of interface parameters can be preset using the parameter entry card. Eight LED-lit pushbuttons located just above the card indicate the status of each parameter, as the card is moved in or out one line at a time. All that is needed to change a parameter is to press the appropriate pushbutton.

The selections are stored in the battery-backed-up Parameter RAM which, in the standard instrument, will retain one complete user-environment specification for a minimum of 90 days, even with the instrument turned off for the entire period. Additional Parameter RAM is available, as an option, to store up to four user-environment specifications. A single keystroke will recall any one of the four and place the 4663 in the selected operating mode, ready for plotting. This ease of changing parameters makes it easy to change baud rate, parity, etc., when switching from one host computer to another. The parameter entry device is discussed in more detail on page 8 of this issue.

Simplified control panel

In addition to the parameter entry device, a series of front-panel controls provide manual selection of a variety of commands. Eight major control groups and two shift keys give you a choice of over 20 functions from an uncluttered, easy to understand front panel.

The selections and functions provided on the parameter entry device and the front panel provide great flexibility in how the plotter is to be used. Few, if any, selections are required to "get a plot." However, the operator can exercise considerable local control over the production of a plot without requiring extensive and cumbersome host computer support. For instance, graphics which have just been previewed at high speed on a graphics terminal can be replotted as a C-size drawing, at maximum speed, using a ball-point pen and coarse alpha characters (which are faster). They can then be plotted again as an A-size drawing (in vertical format as for a notebook) using a wet-ink pen and enhanced (high precision) alpha characters. Both plots can be drawn without making changes to the host program.

Such local configuration capability is ideal for applications where the plotter is used for output involving several media and pen types, several different presentations (standard drawings, text illustrations, overheads), or several different hosts or local storage devices. The 4663 is smart enough to provide the desired output under this wide range of conditions.

The initial set-up selections provided on the parameter entry card allow the 4663 to be quickly tailored to the type of pen to be used, the type of media, and the desired initial viewport size. The front-panel PAGE function can be used to locally calibrate the plotter to the absolute media dimensions, which will exhibit minute size variations as a function of humidity and printing variations.

In many instances it is desirable to use only a portion of the page for plotting. This is accomplished through the SET VIEWPORT function. A special often-used viewport, such as a mailing label, can be saved as a "user-defined" page via the parameter entry card. The viewport can also be set by the host computer via the VIEWPORT command.

In some applications you may want to digitize a drawing or plot and transmit the data to the host or a terminal. Digitizing commands, the front-panel POINT functions, and the joystick make this easy to do.

Other front-panel controls let you operate the plotter on- or off-line and in a local or remote mode. Pen force controls provide for fine-tuning the individual pen forces selected by the parameter entry device, for selecting a desired pen, and for raising or lowering the active pen.

Extensive firmware

Extensive firmware is an important key to the versatility and operating ease of the 4663.

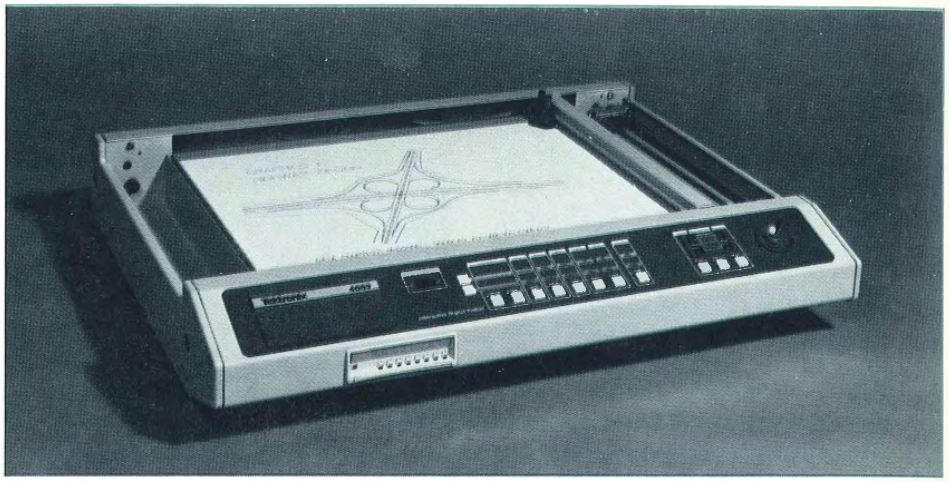


Fig. 1. The 4663 Interactive Digital Plotter provides the versatility of a large plotter in a convenient and easy-to-use C-size configuration.

Operating commands for the 4663 can be divided into six major groups:

Interface commands
Plotter device commands
Graphic plot commands
Transformation commands
Alphanumeric commands
Graphic input commands

As a typical example of the firmware capability resident in the 4663, let's consider the transformation commands. These commands allow you to modify graphic or alpha commands from a host that may have a minimal graphics capability. For example, motion commands can be translated, scaled, rotated, and/or skewed before being plotted. All of these modifications can be accomplished by the control firmware in the plotter, without modifications to the host or its data.

Transformation is accomplished by multiplying each incoming command by a transform matrix containing the desired modification parameters (such as rotation, scaling, etc.).

Transform commands also allow you to change the viewport size and location, and to define window parameters. The window parameters are established in World Units, i.e., inches, pounds, angstroms, etc., and define the values of the edges of the viewport. Another command included in the transforms is the clipping control command. This command allows you to clip at either the viewport or the page boundary.

A comprehensive set of graphic plot commands allows flexibility in the choice of dimensional coordinate units, the type of line to be drawn (solid, dashed, etc.), the coordinate type (absolute or relative), and the choice of which pen will be drawing.

The choice of dimensional coordinate units, or graphic units, includes World Units and Device Units. (World Units are the units defined by the current window.) When Device Units are chosen you have a further selection of Addressable Device Units (ADUs), Graphic Device Units (GDUs), or millimeters.

ADUs provide device-dependent device addressing with a numeric addressable range of from 0 to 4096 on the longest axis of the viewport. The range of the shortest axis is determined by the current aspect ratio.

GDUs provide device-independent device addressing with a numeric addressable range of from 0 to 100 on the shortest axis of the viewport. Using GDUs ensures that any graphics containing only coordinates between 0 and 100 will be plotted without clipping, no matter what the current aspect ratio is. For

millimeters, the numeric range is the actual axis length in millimeters. These units give a plot of the same physical size, regardless of the current viewport size.

Versatile alphanumerics

Graphics versatility in the 4663 is complemented by equal versatility in alphanumerics. Included are a self-contained character generator, provision for up to 15 character fonts (nine of which are resident in the 4663), and a host of commands to operate on the alphanumerics. One font can be designated as the standard font, and another as the alternate. The characters can be rotated, scaled up or down, or slanted, independent of the graphics and all under program control.

There are commands to set the character size and spacing, if you desire other than the default settings. You can also print centered characters for applications such as identifying a line on a graph. And the pen can be moved specified X and Y distances in fractions of the current character size, to facilitate drawing superscripts and subscripts.

It is sometimes desirable to draw alphanumerics in a paragraph format. A Set Margin Separation command activates the right margin and allows you to set the number of character spaces that separates the left and right alpha margins. Carriage Return and Line Feed functions will be automatically performed to draw a string of alphanumeric characters within the margins established.

The alphanumerics capability is enhanced with options that allow down-loadable character sets, programmable macros, and circular interpolation. The latter permits drawing circles or arcs with a single command. For circles, you need only to specify the radius, and the circle is drawn around the current pen location. Arcs are defined by specifying two points on the arc, which begins from its current pen location. You can choose the smoothness of the arc or circle, to meet the need for a quick overview or a high resolution finished plot.

Digitizing capabilities

For some applications it is desirable to digitize the plot on the 4663 and transmit the data to a host or terminal.

The joystick, the crosshair on the pen carriage, and the front-panel POINT switches, which allow the point to be designated as a DRAW, MOVE, or LAST point, are used in this function. Digitizing in one axis only is greatly simplified by using the Joystick Axis Disable command. This command allows you to disable either the X or Y axis, or both.

Block diagram discussion

A block diagram of the 4663 circuitry is shown in figure 3. The 4663 employs a functional bus, which is referred to as the product bus (PBUS). The product bus is a modular assembly consisting of a microprocessor, memory system, power supply, one or more communications interfaces, and several circuit board assemblies which interface and control the axis motors, pen activations, and media advances.

The circuit modules communicate through a standardized 80 lead interconnecting backplane. This functional bus hardware architecture promotes functional partitioning, which enhances product serviceability. It also allows updating the product through advances in technology, without disturbing those modules which are to remain unchanged.

Bus characteristics include non-multiplexed, 16 bit address and 8 or 16 bit data, asynchronous bus transactions of arbitrary length up to 3.8 μs (actual transaction time is defined by the addressed device's speed capability), and a master clock frequency of 14.7456 MHz. Up to eight prioritized DMA devices may be accommodated, with serial poll prioritization of either block mode or character bus DMA transactions. Eight hardware vectored maskable interrupts and one software interrupt are supported by the bus.

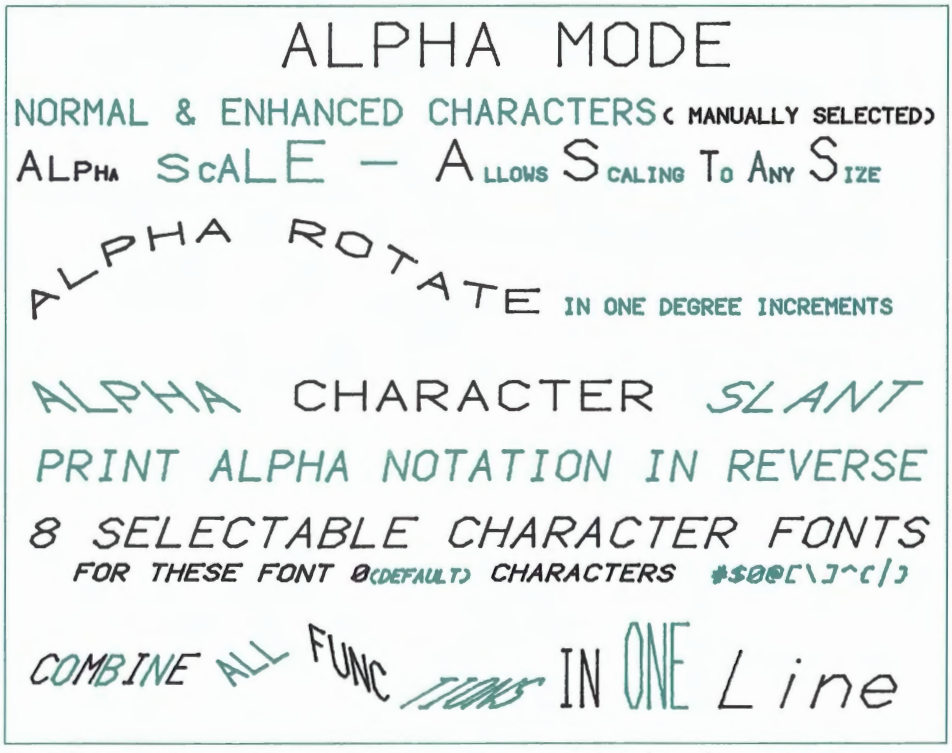


Fig. 2. Extensive firmware lets you draw alphanumerics in a manner that enhances the graphics portion of the plot. Characters can be rotated, scaled up or down, or slanted, independent of the graphics.

A single etched circuit board contains the MC6800 microprocessor, product bus interface, bus controller, RAM, ROM/PROM memories, processor enhancements, and the parameter entry interface.

The bus controller arbitrates interrupt requests to the processor and DMA activity on the bus (including debug system activity). Bus transactions for references to nonexistent or malfunctioning modules/memory are also monitored by the bus controller.

The standard memory system includes eight kilobytes of static RAM, with about 5.5 kilobytes available as a buffer pool which may be used for storing input commands, output data responses, programmable macros, nested transforms, or down-loaded character sets. The parameter entry device uses 128 bytes of battery-backed-up CMOS RAM for parameter storage. This can be expanded to 512 bytes to accommodate multi-user operating environments.

Up to 34 kilobytes of ROM and 6 kilobytes of PROM can be accommodated in the standard memory system. An additional 2 kilobytes of PROM, used for firmware patching, can reside in the parameter entry module.

The memory system is designed to provide wide latitude in ROM versus RAM allocation. (See figure 4). Mapping the I/O space for registers at the top of address space removes the restrictions of where ROM and RAM may extend in address space. The 6800 processor hardware vectors are placed down two kilobytes in the memory map. This isolates the peripheral circuit modules from alternative microprocessor implementations, and allows for flexible partitioning of ROMs, PROMs, and RAMs.

Multiple resident interfaces are accommodated on the bus without compromising available address space. This is done by bank switching the Interface Handler ROM, so that only the firmware of the active interface is mapped onto the bus.

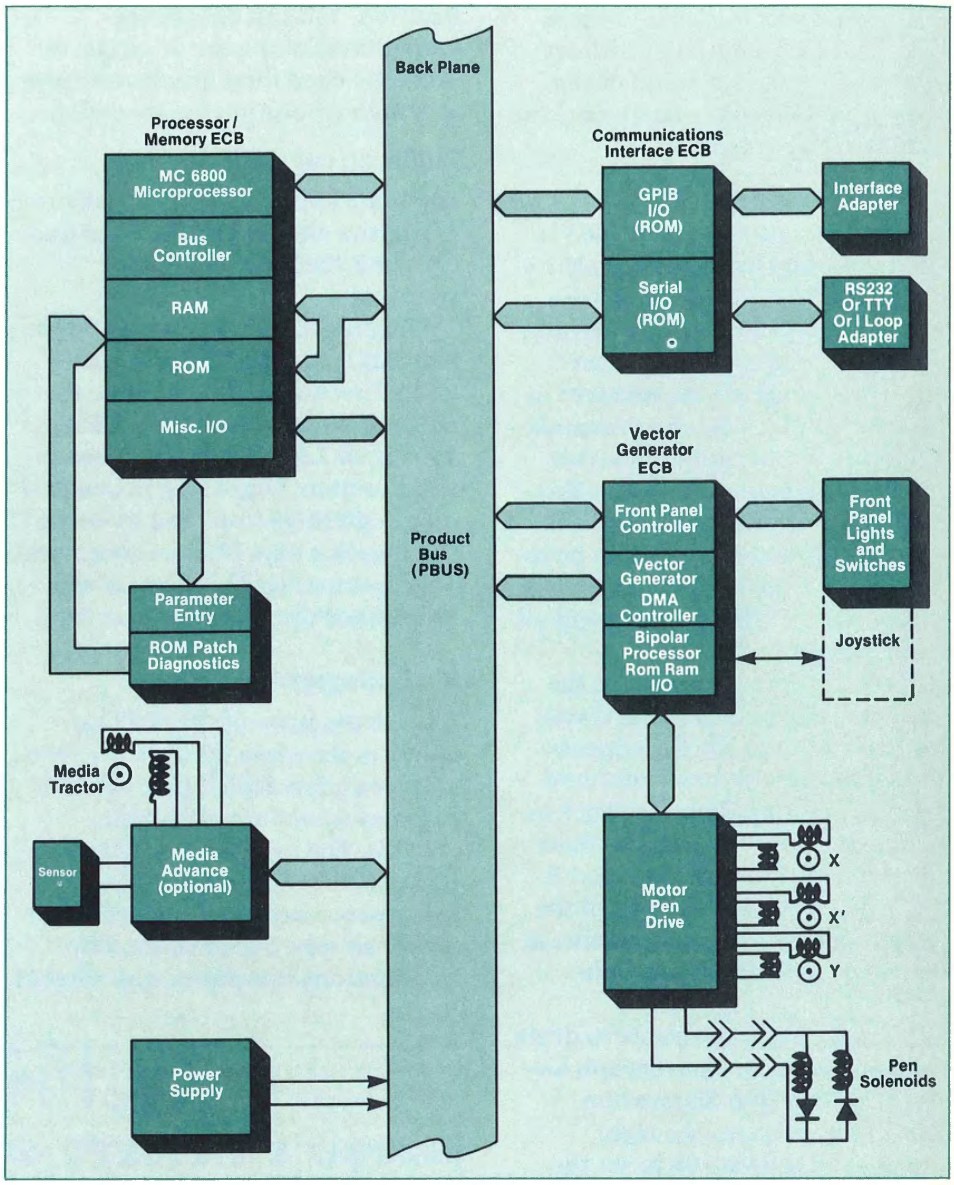


Fig. 3. Functional block diagram of the 4663. An 80 lead backplane provides interconnection for plug-in modules.

RAM address space is located at the bottom of memory address space and builds up from the bottom. Additional RAM in excess of the standard 8 kilobytes can be added in 1 kilobyte increments. However, it must physically reside on other than the processor/memory module.

The firmware patch

As the 4663 is applied to new applications it is sometimes necessary to modify or correct one or more of the mask programmed ROMs. This is accomplished in the 4663 through the use of a firmware patch module. The module, which plugs into a board slot in the parameter entry device, contains a field programmable logic array (FPLA) and a fusible-link PROM or EPROM. Interconnects and circuitry required to use the firmware patch reside on the processor/memory board.

The port through which the ROM patch communicates with the system is also used for installing diagnostic firmware for troubleshooting.

The FPLA may be regarded as a partially-populated PROM responding to any programmed address within a 16 bit field. The total capacity of the FPLA is 48 bytes. The device is applied in product maintenance by programming the address(es) of the ROM byte(s) which the firmware engineer identifies as requiring modification. Once these addresses have been identified, the firmware designer then defines the overlay bytes. The FPLA, once programmed with input and output terms, will respond to specific programmed addresses on the bus by disabling the main system memory and overlaying the new data byte. Patching ROM in this fashion imparts no extra time burden on the processor.

If the modification requires additional firmware bytes, one or two patch PROMs may be included on the ROM patch. The expansion bytes are accessed simply by overlaying three bytes in the original, to insert a jump instruction which will transfer control to the start of that particular code enlargement in the patch PROM. At the end of the extra code section, another jump instruction returns the processor to the original code.

4663 interface modules

One parallel and three serial interface conventions are supported by the 4663 through standard and optional interface modules. The 4663 will accommodate the GPIB (parallel) Interface Module and one of three serial Interface Modules, simultaneously resident on the bus. Only one of the interfaces, however, may be active at a given time. As the interface firmware ROM is resident on the particular interface, the 4663 is easily up-graded by simply installing an optional module in the bus.

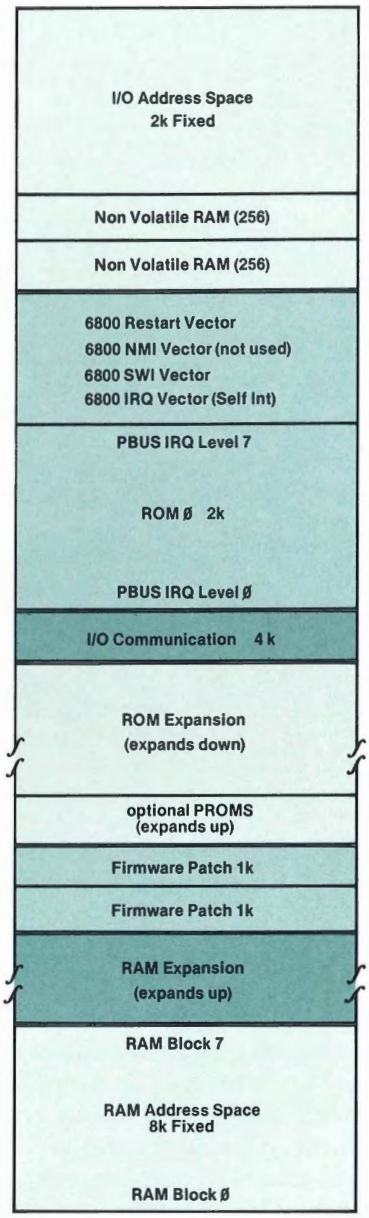


Fig. 4. Memory map for the 4663. Mapping I/O space for registers at top of address space removes restrictions on where ROM and RAM may extend in address space.

Serial interface conventions accommodated by the 4663 include:

1. RS 232 A/C at up to 9600 baud, full duplex, with selectable DC 1/DC 3 control and selectable hardware receive flagging for local host environments.
2. 20/60 mA Current Loop with external clock capability.
3. TEKTRONIX 4010 Series Terminal-compatible TTY interface which accommodates data communication rates up to 307 kilobaud.

Vector generation

The time-intensive tasks of vector generation and motor control are handled by a bipolar microcontroller (Signetics 8X300) in the 4663. By relieving the main system processor of these tasks, its intelligence is made available for product performance enhancements.

The microcontroller on the Vector Generator appears as a DMA device to the PBUS. Communication between the main system processor and the Vector Generator employs:

1. a circular queue in RAM which contains command/argument information,
2. references to ROM-based fixed constants, and
3. references to RAM-based operating environment variables.

Control of Vector Generator activity is exercised through hardware registers in I/O space. Flagging of the main system processor by the Vector Generator, of task status, employs the interrupt structure supported by the bus.

Non-functional bus oriented communication by the Vector Generator, with the Motor Drive Module, transports data representing the digital rotor position of the three motors driving the X and Y axes, pen selection, and pen force.

The vector generation process employs digital integrators implemented in the microcontroller, rather than conventional hardware rate multipliers. Digital integrators exhibit minimum frequency modulation (FM) at low axis drive rates, whereas rate multipliers will exhibit significant FM at these rates.

Minimizing FM of the axis drive rates results in reduced plotter line aberrations and measurable improvements in linearity.

Parameter Entry Device Simplifies Plotter Set-up and Servicing

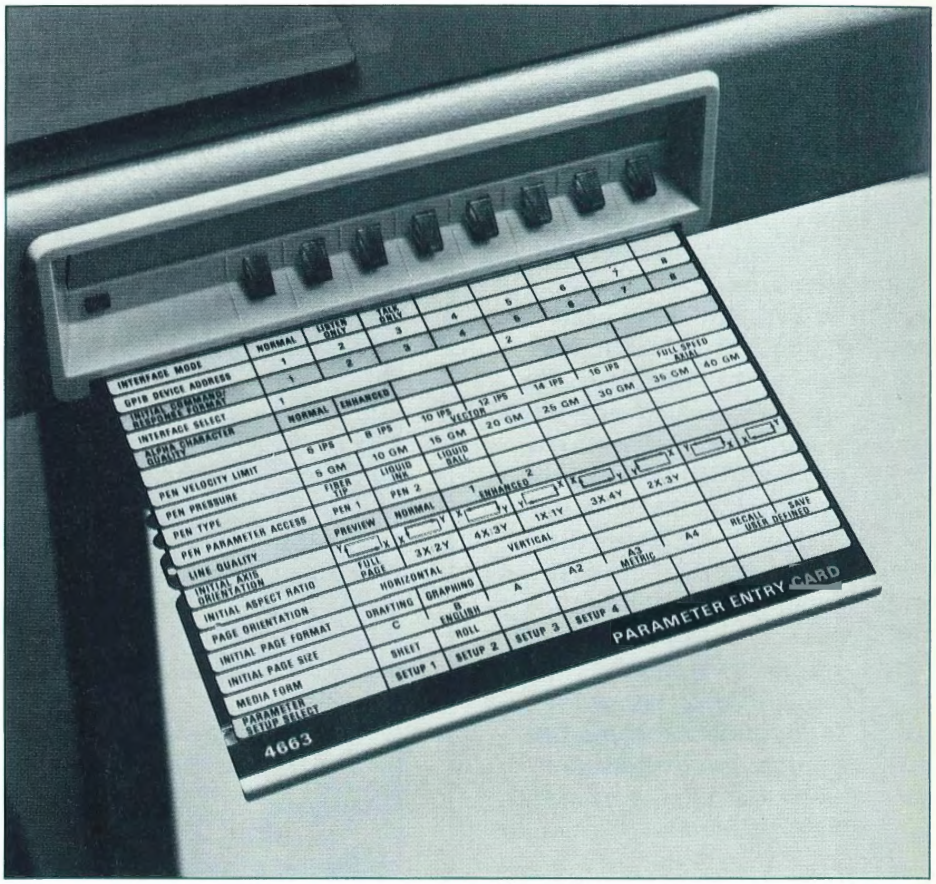


Fig. 1. Parameter entry device simplifies plotter set up and servicing.

One of the deterrents to using large, versatile plotters or other sophisticated peripherals is the set-up time required. The 4663 features a unique solution to this problem.

The parameter entry device provides a convenient means of identifying and selecting operating parameters without the use of conventional rear panel switches and jumpers, and volumes of user manuals.

The basic elements of the device include: the parameter entry card, which serves as a menu of the parameters and values available; eight LED-lit switches, which indicate the current selection and provide a means of changing the selection; the initialization LED, which indicates that the card should be placed in the "home" position to synchronize the system; three buffer registers, which provide temporary storage of the LED, switch, and interrupt status; and a small portion of battery-backed-up CMOS RAM (located on the processor board), which provides long-term parameter storage.

The parameter entry device is not product bus (PBUS) compatible as a stand-alone module, but communicates with the PBUS through an interface located on the processor board.

How it works

When the 4663 is turned on, the parameter entry card is placed in the "home" position (fully inserted) to initialize the system. The set-up that was in use when the plotter was turned off is stored in CMOS RAM (Parameter RAM).

Parameter RAM serves as a condensed copy of all hardware and RAM based configuration registers. The hardware configuration registers are output ports for baud rate selection, interface enabling, etc. The RAM based configuration registers serve as common system variables which are referenced by the operating system.

The user may determine how the plotter is set up by withdrawing the parameter entry card one line at a time, noting the switch illumination. The movement and position of the card is sensed by three photo-transistors. A quadrature detector (Motion Detector) detects the direction of card movement by comparing the order in which serrations along one edge of the card, cover, or uncover, two of the photo-transistors. The third photo-transistor senses when the card is moved to the home position.

Each time the card is moved in or out, an interrupt is generated that signals the processor to up-date a position register in main system RAM. The position register content is used as a pointer to address the Parameter RAM. With each card movement interrupt, the main system processor uses the position register to fetch current line status and store the information in the Parameter LED register, thereby illuminating the appropriate switch.

When one of the eight switches is pressed to change a parameter selection, an interrupt is generated that calls for the processor to read the switch register and up-date CMOS RAM and the Configuration and LED registers. Through this user-initiated action the operating characteristics of the 4663 are changed to the new selection. At the same time, the selection is recorded so that the 4663 will power up in the new configuration.

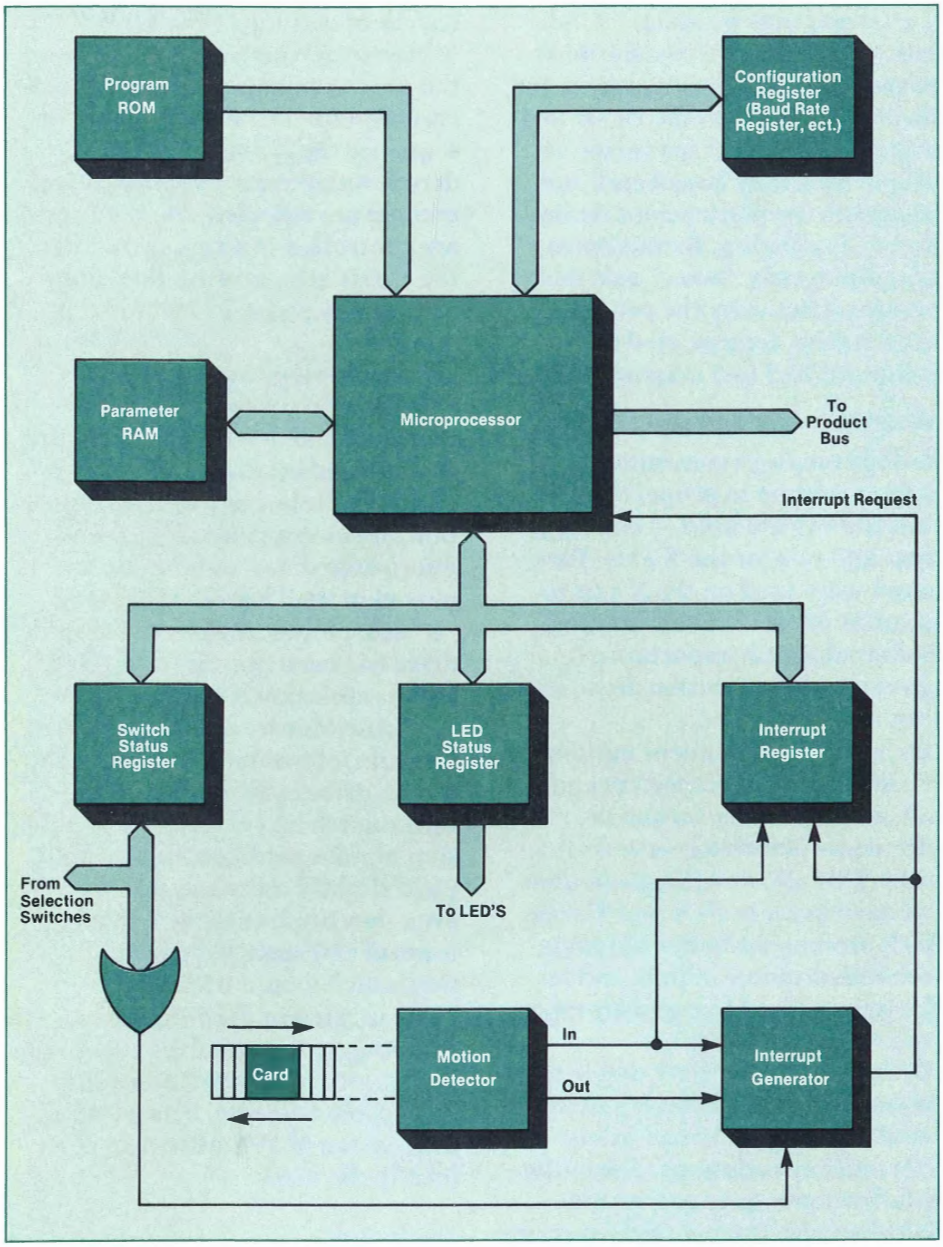


Fig. 2. Simplified block diagram of parameter entry device.

A servicing tool

The parameter entry device is also an important tool for servicing the 4663. Two positions on the parameter entry card are dedicated to this function. The EXECUTE SELF TEST position allows you to quickly check that all front-panel lights are working, and then to initiate a program to draw a test plot. The plot, properly executed, assures the mechanical portions of the plotter are working properly.

In the ERROR DATA position, the LED-lit switches serve as an error readout display. When the ERROR CODE switch is pressed, a code pattern indicating the type of error will be displayed. This may indicate system or operating errors such as insufficient RAM, a ROM check error, framing error, etc.

An optional diagnostics package consisting of a diagnostics card, a diagnostics printed circuit board module, and a manual, offers more extensive troubleshooting capability. The diagnostics card replaces the parameter entry card and directs the test technician through a logical series of tests of the plotter hardware.

The printed circuit board module contains sockets for three 16 kilobyte EPROMs, a RESTART switch to reset the whole system, and a multi-position rotary switch to select tests. Several test pins on the module provide convenient connection of a test oscilloscope.

The tests are run sequentially and are structured in ascending orders of complexity relying on hardware proven operational in previous tests.

Basic processor operation is verified, followed by tests of the Parameter Entry Device LED display and switch operation. Verification of Parameter LED and switch registers is essential as they will be used to display test results and enter test directives. Tests of the main system RAM, the interrupt functions, Parameter Card Position Encoder, CMOS RAM, and ROM checksum follow. Front panel controls are then checked. Both GPIB and Serial interfaces are checked, and then a series of tests are run on the vector generator functions. The motor and pen drives are exercised, and a calibration test is performed. A system test draws a plot which exercises both pens. The final test is a media advance test, if that option is installed in the 4663.

The parameter entry device LEDs indicate when a particular test is successfully completed or, in case of a failure, which type of failure occurred.

Integral with vector generation is the process of velocity profiling. If the plotter is to draw lines with a minimum of aberrations (wiggles, overshooting, etc.), the acceleration and deceleration of the axis must be tightly controlled.

In the 4663, velocity profiling is implemented by controlling the axis velocity as a function of position. The vector generator references a table stored in ROM, which contains the information of desired velocity versus position. The table has been optimized for the characteristics of the 4663 mechanism and drive system, resulting in 600 ips² rate of acceleration without adversely impacting the plot quality.

The seldom-specified "rate of acceleration" is a true indicator of a plotter's throughput capability. It is generally more significant than the plotter's maximum plotting speed, when one considers that often the bulk of an "average" plot is composed of short vectors (0.5 in).

Flexibility of the plotter, in its accommodation of a variety of pen types and enhanced line quality modes, is provided by allowing the user to specify one of four acceleration rates. The acceleration rates of 240, 300, 400, and 600 ips² are selectable on the parameter entry card and may be changed while the 4663 is plotting.

Pen speed is also controllable by the user and may be assigned independently to the two pen stations. Pen speed limits of 6 to 16 ips vector velocity, in 2 ips increments, or 16.5 ips axial velocity (23 ips vector velocity at 45°), may be selected and assigned to the pen stations while the 4663 is plotting. To maximize throughput, only "draw" axis motions are affected by the pen speed limits; moves are executed at maximum (16.5 ips) axial speed.

Axis drive motor and pen control

The 4663 employs conventional 1.8° stepping motors to propel the axes. Three motors are used — one for the Y axis and two for the X axis. Two motors were used on the X axis to minimize the drive cable lengths, which is of prime importance if high rates of aiceleration are to be supported.

By having independent motors, each driving their respective end of the Y axis assembly, torque requirements per motor were reduced. This allowed the use of identical devices for both X and Y axes, which promotes a better dynamic mechanism/motor match, and results in improved line quality for a given rate of acceleration.

Orthogonality of the Y axis arm with respect to the drawing surface is assured, irrespective of minor cable tension variations, due to the initialization sequence that the 4663 observes. During the power up sequence, the plotter establishes a mechanical reference for each axis. The X axis, however, has two reference sensors (one at each end of the Y axis arm) which are used to align the arm as well as establish the reference point. During the power up sequence the X axis motors are driven independently. Once the references are detected, the X motors are controlled in a fashion to align the Y axis arm, and are thereafter electrically phase locked to each other.

A micro-stepping technique is employed to control the motors. Conventional drive techniques, and their attendant drawbacks of resonance and relatively coarse resolution, are circumvented by the micro-step drive. Originally employed in the TEKTRONIX 4662 "B" size plotter, the micro-stepping drive has been refined for the 4663. Drive resolution is 6400 steps per motor revolution at a maximum of 42 oz.-in. of torque provided by the motor/drive combination. Conventional drives of full-step or half-step bipolar configurations would yield slightly more torque. However, they are limited to a maximum of 400 steps per revolution which would translate to 0.004 in./step in the 4663. Microstepping, which involves energizing the motors with quadrature sine and cosine currents, nets a linear translation of 250 millionths of an inch in the 4663.

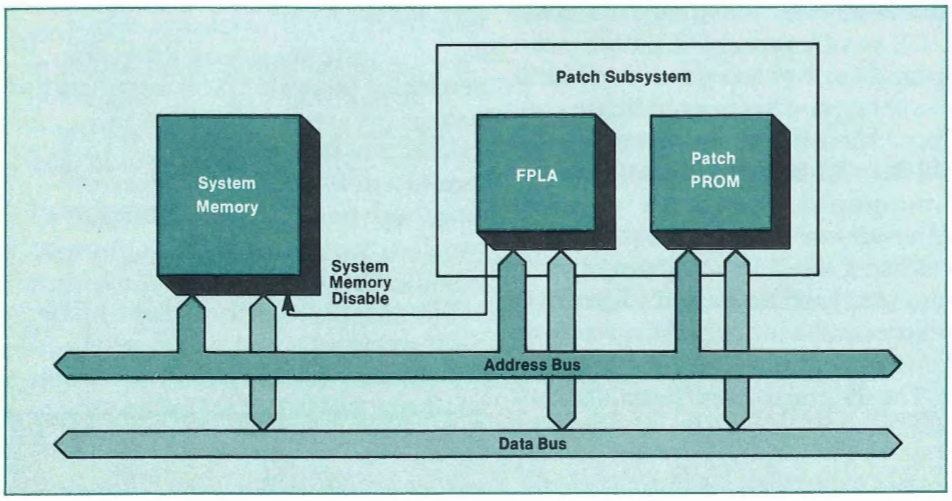


Fig. 5. Simplified block diagram of the firmware patch. When the FPLA receives an error address, it disables system memory and places corrected instructions from the patch PROM, on the data bus.

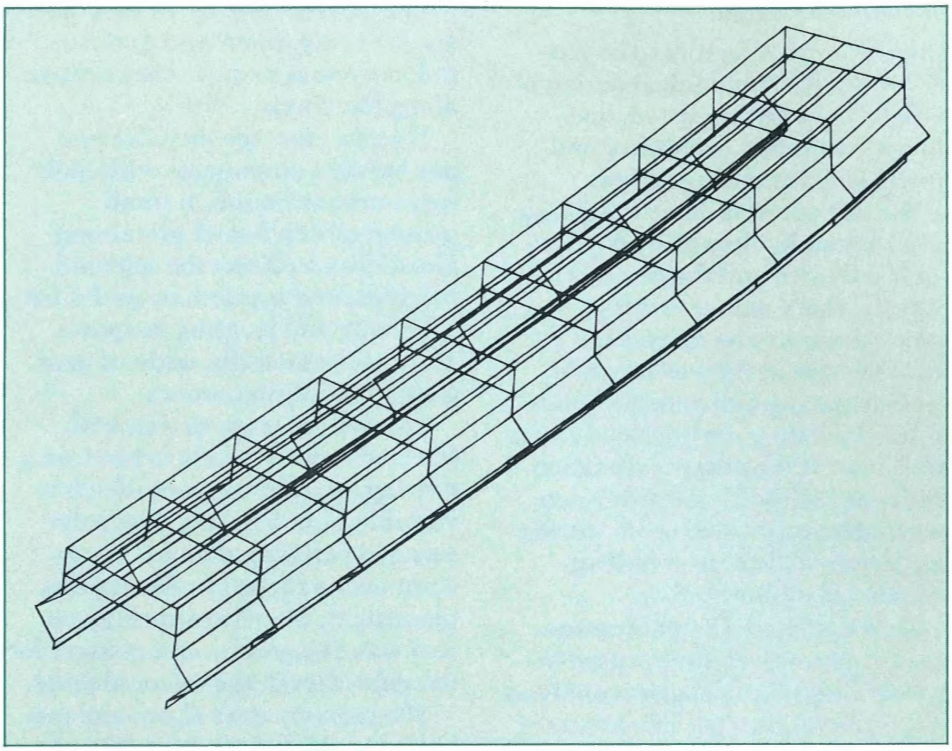


Fig. 6. Finite element analysis was used in designing Y axis arm. Box structure at top of arm provides rigidity with light weight.

Six transconductance-mode, high-efficiency, PWM (pulse width modulated) drive amplifiers power the three axes motors. References for the amplifiers are derived through a time-division-multiplexed D/A converter. The D/A converter operates at a 2.16 μs conversion cycle, with a total of seven conversions to be performed. Converted are the sine and cosine data for the three drive motors, and the pen force. Data from the vector generator, representing the digital motor position for the drive motors, is routed through a 256 x 8 ROM look-up table which provides sine ϕ and cosine ϕ data for each motor. The pen force data byte does not get translated by the ROM and is, instead, applied directly to the D/A. An analog de-multiplexer extracts the reference potentials and buffers them for use by the motor and pen amplifiers. Pen force data and pen selection are contained in an 8 bit data byte. A 7 bit field represents the pen force; the remaining bit selects which pen is active.

The pen drive circuit is configured as a bipolar, linear, transconductance amplifier. Commutating diodes mounted in the pen carriage steer the current to the selected pen, minimizing the number of electrical conductors needed. The pen force, either default for a specific pen type or user definable, is assigned by the main system processor when the pen station is characterized by the user through the parameter entry device. Whenever the pen station is activated, either under program control or from the front panel, the specific pen force is invoked. This allows the user to intermix fiber tip, wet ink, liquid ball, or special pens, and yet maintain optimum force characteristics for each type. Furthermore, each pen station has a vernier pen force control on the front panel which allows for fine adjustment while the 4663 is plotting. The range of adjustment is ±25% of the preselected pen force.

Front panel and joystick

Front Panel switches are polled by an on-board serial memory. Debouncing in both activation and deactivation is provided by votive logic. Once a valid state change has been decoded, the main system processor is interrupted by the Front Panel Controller which resides on the Vector Generator. The benefit to the user is a functional, live, front panel through which plotter functions may be manipulated. For example, the plotter may be placed in the "Pause" mode, which allows the user to annotate a plot and then resume plotting without data loss. Communication of the system processor with the front panel displays is through a serial data port, which minimizes electrical cabling requirements.

A two channel voltage-to-frequency converter interfaces user manipulation of the joystick with the vector generator.

The circuits sensitivity was made non-linear to maximize the human factors of cursor positioning. The joystick axis may be independently activated under program control to assist in digitizing graphic data which has Δ in one coordinate fixed. With suitable support software, the tedium of digitizing may be minimized by having the host increment one axis, following a graphic input command, and requiring the user to locate only the remaining axis before inputting the next point.

Mechanical design

There are many factors to be considered in the mechanical design of a plotter — plotting speed, line quality, accuracy, reliability, and quietness, to name just a few.

Plotting speed is determined to a large extent by the ability to move the Y axis arm and the pen carriage rapidly. The Y axis arm is the greatest mass to be moved and must be kept as light as possible, yet be rigid enough to resist bending and twisting during rapid starts and stops. If the natural vibration frequency of the Y axis arm is too low, vibrations which occur during operation of the plotter will adversely affect line quality.

The TEKTRONIX 4081 Interactive Graphics System was used in performing a finite element analysis of the pen rail design. The effects of doubling the side thicknesses, top thicknesses, both side and top thicknesses, or adding a box structure to the top of the arm, were explored. Different types of material were also evaluated.

The final design is that pictured in figure 6. The arm is an aluminum extrusion 22.77 inches in length, with a wall thickness of 0.062 inch. The top of the rail is an enclosed box.

Two separate cable, pulley, and stepping motor systems drive the Y axis arm, one at each end. This, in effect, cuts both the load and the length of the X axis cable in half, thus increasing the stiffness of the drive system significantly. This requires careful matching of the motor capstans to ensure proper tracking of both ends of the Y axis arm.

Alignment of the Y axis arm is done automatically by a routine employing photo-optic sensors each time the plotter is powered up. Although there is no mechanical connection between the two motors, external forces rarely cause a misalignment since the dc current levels in the motors produce a very high holding current.

The pen carriage drive uses only one stepping motor and a cable/pulley system to move the carriage along the Y axis.

The pen carriage includes two pen holder components with their respective solenoids, a small printed circuit board containing two diodes to direct the solenoid currents, and a crosshair useful for digitizing and locating purposes. The entire assembly, without pens, weighs about two ounces.

The solenoids are driven with selected current levels to produce a writing force on the pens which is variable from 5 to 40 g. Since the selected pen force should be constant over a range of solenoid displacement, the return spring system was designed to compensate for irregularities in the solenoid force.

The moving mass of pen and pen holder is about 15 g. To write consistently with a pen force as low as 5 grams required "fine tuning" the solenoid, return spring, and bearing friction design parameters.

The frame of the plotter consists mainly of aluminum extrusions, resulting in a lightweight, rugged, yet inexpensive structure. Front and rear panels are also aluminum extrusions. Structural foam, which combines good appearance with rigidity, light weight, and low sound transmission, is used for the side panels.

Other steps taken to ensure operating quietness include isolating the X and Y axis drive motors and the bottom pan, from the plotter mainframe.

Serviceability is always a concern in mechanical design. In the 4663, the plotting surface is hinged at the rear. Lifting the front of the plotting surface gives easy access to the electronic circuitry. A support rod keeps the plotter open, freeing both hands for servicing. Printed circuit boards and the entire power supply unit can be easily removed and replaced.

Summary

The 4663 Interactive Digital Plotter combines the versatility of a large plotter with the convenience and operating ease of a small plotter. Programming ease enhanced by extensive firmware minimizes set-up time and makes the 4663 ideal for the multi-user environment.

Acknowledgements

The 4663 is the culmination of the combined efforts of many people. Not all can be mentioned here, but a special note of thanks is due Bill Yoresen, Project Manager, for his capable direction of the program; Dick Duggan, assisted by Dave Hoskins and Dick Sollars, for the mechanical design; Kathy Eastman, for her contribution to software; and Byron Fisher, for his valuable marketing input.

Updating the Industry-Standard 100 MHz Portable Oscilloscope

Harold Busch

Hal, a long-term Tek employee, began his career in the test department in 1955. He has a broad range of experience in the various areas of manufacturing, and currently is Production Manager for the 460 and 470 Series Oscilloscopes. Hal was Project Manager for the 465B.

Standards change very slowly, sometimes never. And that is as it should be, for standards form our basis for comparison. Soon after its introduction, the TEKTRONIX 465 became the recognized industry-standard for portable oscilloscopes. In the mark of a good standard, it has changed little since its introduction.

Now, the new 465B updates the industry-standard with new display capability, faster sweeps, and even better reliability.

Front-panel layout is essentially the same as the 465 so operator retraining is unnecessary. The major change that will be noted is the restyled pushbuttons. They are smaller, giving the front panel a more open appearance and providing easier function selection.

Display improvements

The vertical mode selection pushbuttons are changed from the self-cancelling type to the push-push type allowing you to display any combination of vertical signals and external trigger you desire. For example, you can look at either or both vertical channels, their sum or difference, and the external trigger, simultaneously.

The trigger view function is designed to provide zero-delay between the vertical channels and the trigger view, enabling you to make accurate time comparisons between the signal and the trigger, even at the faster sweep speeds. The quality of the external trigger view channel makes it useful as a third input channel with a sensitivity of about 100 mV per division.

Improved vertical preamplifier performance permits replacing gain switching with up-front attenuation, and yields a finer trace width at the maximum sensitivities.

Horizontal versatility is expanded to complement the vertical improvements. Top sweep speed is increased to 2 ns per division for greater resolution in examining fast rise time signals. And alternate sweep switching lets you look at both A and B delayed sweeps simultaneously, at full screen width. A separate intensity control for B sweep lets you set the contrast between A and B sweeps, with vertical separation between sweeps provided by the trace separation control.

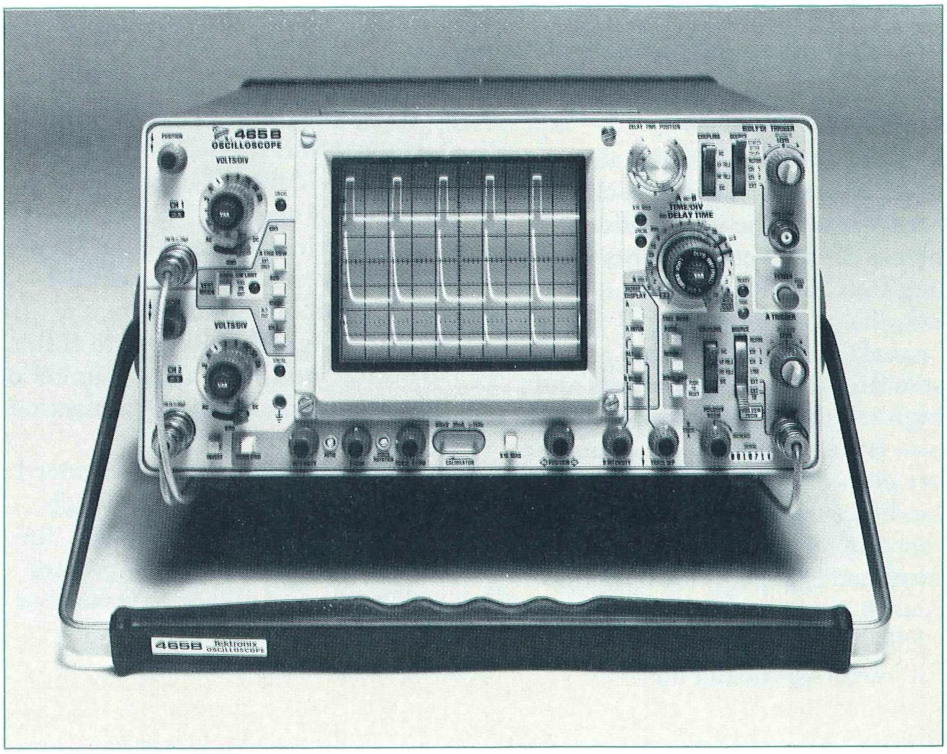


Fig. 1. The new 465B. Front-panel layout is almost identical to the 465. New features include a wider choice of displays and zero-delay external trigger view.

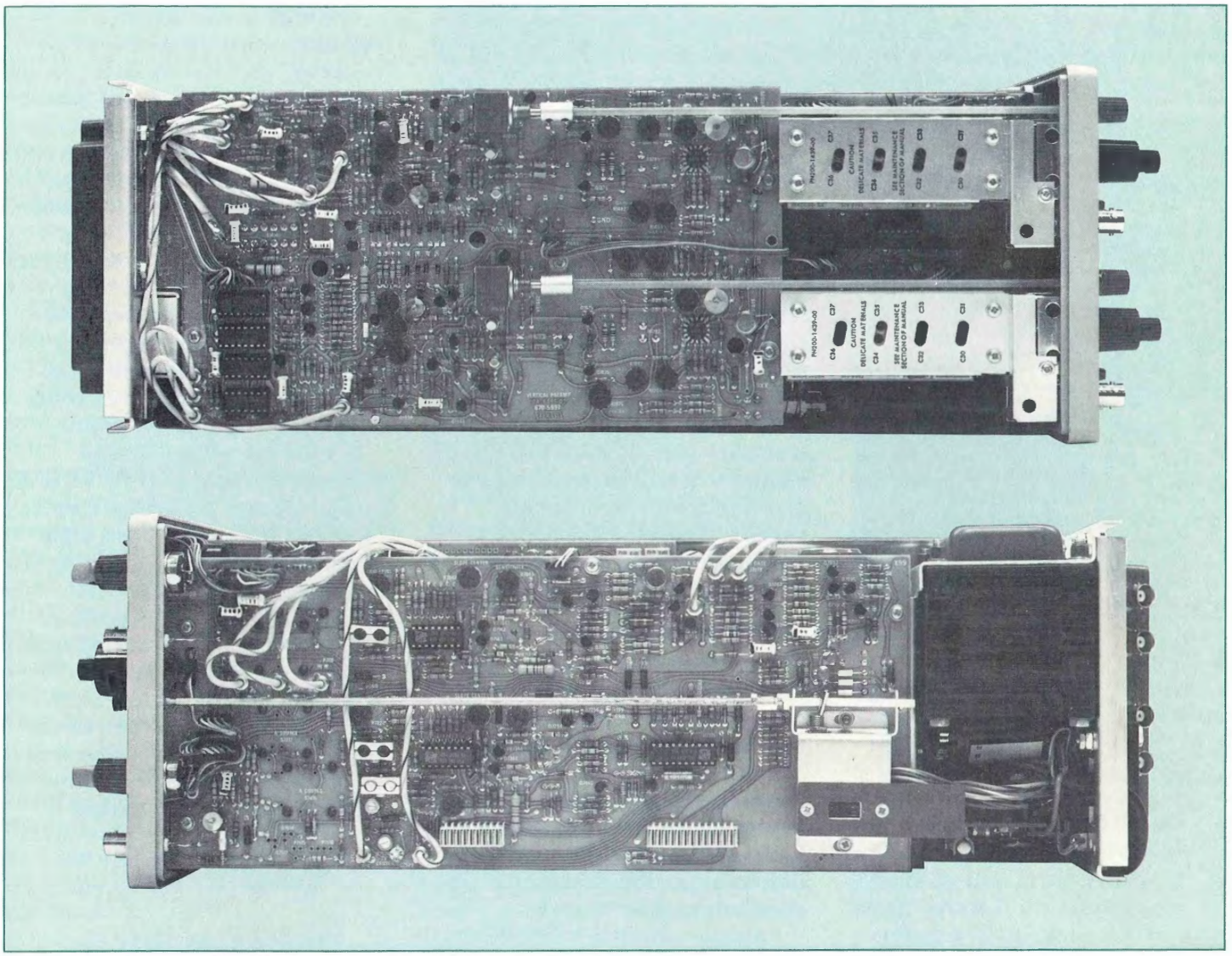


Fig. 2. Internal views of vertical (top) and horizontal (bottom) circuitry show reduced component count through the use of integrated circuits. Layout symmetry makes 465B easier to build and maintain.

Servicing improvements

A glance inside the 465B cabinet reveals even more extensive change. An all-new vertical amplifier replaces discrete components with integrated circuits. Operational amplifiers replace vertical "tweaks." And new switch assemblies provide easy access and high reliability. Soldered-in leads now have connectors, and jumpers are placed at strategic points to facilitate troubleshooting. Transistors and integrated circuits are mounted in sockets for the same reason. Front panel indicators use LEDs instead of incandescent bulbs for longer operating life.

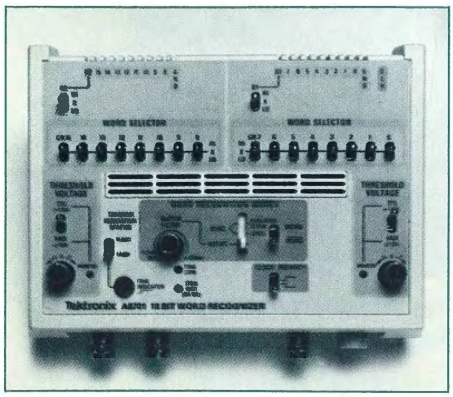
While the improvements in performance and serviceability were being considered, the buildability of the 465B was receiving equal attention. Printed circuit board layouts allow maximum use of automatic component insertion; the newly-designed switches are easier to build; and the reduced number of adjustments minimizes calibration time.

The end result is a new standard for portable oscilloscopes which offers new display capabilities, improved serviceability, still greater reliability, and all at no increase in catalog price.

Acknowledgements.

Many people are involved in the design of a new product. Special recognition is due Wayne Kelso for the sweeps, Jim Kuhns for the vertical, Ron Roberts for the alternate sweep switching, and Doug Stroberger for the zero-delay trigger view. Walt Neff and Merle Elkins provided valuable assistance in smoothing the path to production.

New 18 Bit Word Recognizer



The A6701 Word Recognizer

A new 18 bit word recognizer, the A6701, provides cost-effective, easy-to-use digital triggering for portable and laboratory oscilloscopes and other logic display products.

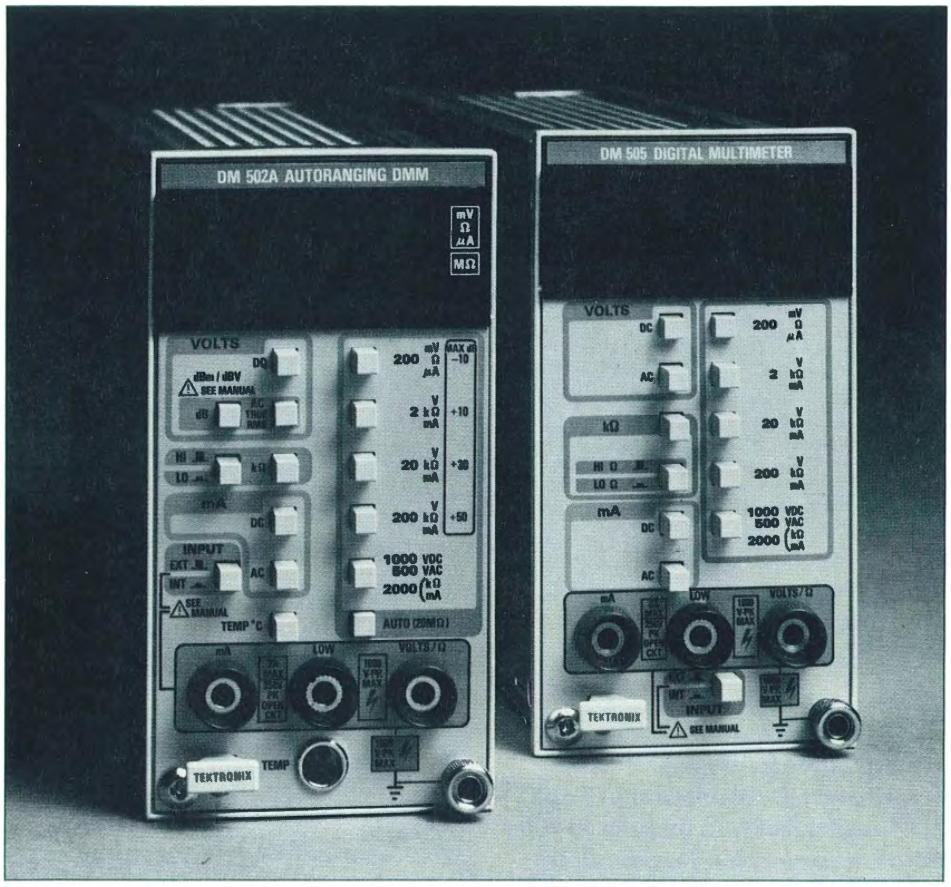
The A6701 consists of a control pod, separate power supply capable of powering two control pods, and a set of accessories. Up to four word recognizer pods can be linked together to provide 72 bit capability.

The unit can be operated in either synchronous or asynchronous mode with a choice of level or qualified clock output in synchronous operation.

Preset TTL or variable threshold voltage selection, and variable-width glitch filter add further versatility. The clock rate is 50 MHz at 18 bits.

Connection to the trigger inputs is via two 10-wide lead sets. An optional adapter accommodates the P6451 logic analyzer probe.

Two New Digital Multimeters for TM 500



The DM 502A and DM 505 Digital Multimeters

Two new 3½-digit multimeters, the DM 502A and DM 505, bring new measurement capability and operating ease to the TM 500 digital multimeter family. Seven measurement functions make the DM 502A the most complete 3½-digit DMM available. The DM 505 is a five-function DMM (dc and ac volts, dc and ac current, and high/low resistance), ideal for applications where low cost is paramount.

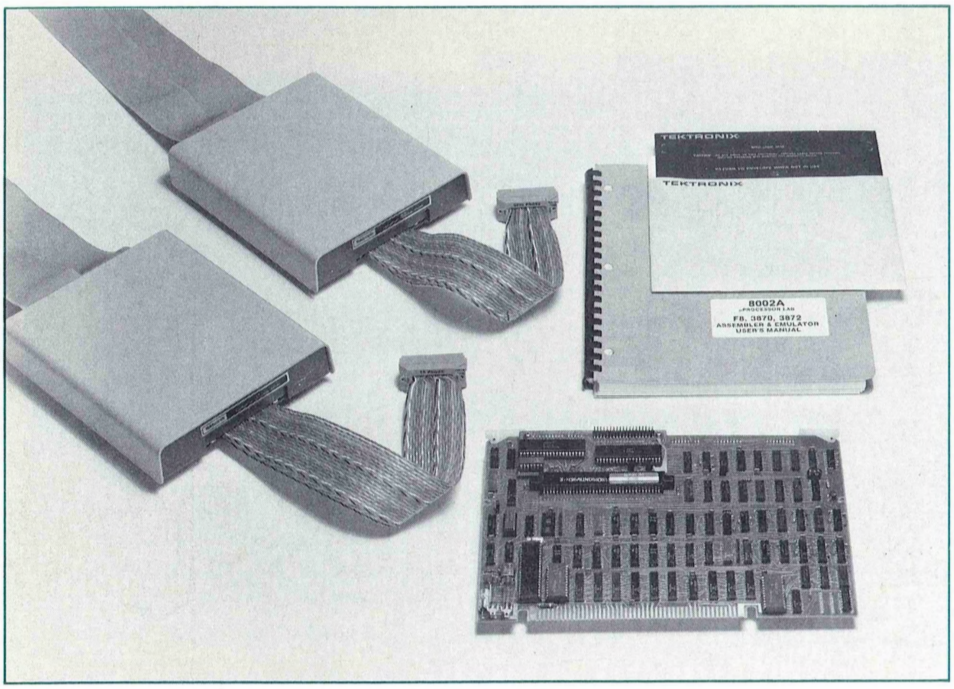
In addition to the basic DMM functions (dc and ac volts, dc and ac current, and high/low resistance), the DM 502A offers dBV and dBm measurements, temperature measurement, true rms readings, and autoranging for volts, ohms, and dB measurements.

The DM 502A's unique combination of autoranging and dB measurements makes it an excellent choice for communications applications.

Probe temperature measurement, pioneered by Tektronix, has been enhanced in the DM 502A. Temperature measurement range at the probe tip is −55°C to +200°C, and the entire P6601 probe tip and cable are specified for immersion to 140°C.

Pushbutton selection of all functions and ranges, plus easy-to-read 0.5 inch LED display digits, make the DM 502A and DM 505 fast and easy to use. A choice of front panel or rear connector inputs is pushbutton selectable.

8001/8002A Microprocessor Labs Add Support for F8, 3870, 3872, and 1802.



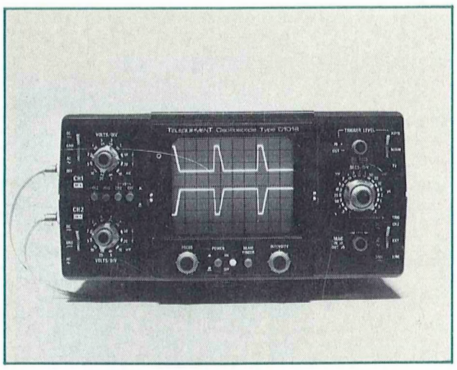
The F8, 3870, 3872 Emulator Processor and Prototype Control Probes.

Two new emulator processors extend the TEKTRONIX 8001/8002A Microprocessor Development Labs (MDL) capabilities to include the 1802 microprocessor, the F8 microprocessor, and the 3870 and 3872 microcomputers. This expanded capability is in addition to the present support for the 8080A, 8085A, 6800, TMS9900, and Z80A.

TEKTRONIX MDLs offer the 3870 designer greater design-environment support than previously available for these chips. The 8002A's assembler/linker features provide efficient program coding to make use of the limited amount of memory contained in these chips.

The 1802 and F8/3870/3872 emulators are similar to other currently available TEKTRONIX emulators — for each, a complete software debugging system, in-prototype emulation, and real time prototype analysis are available.

Low Cost 15 MHz Scopes Excellent Value



The Telequipment D1016 Oscilloscope

Two new 15 MHz dual trace models have been added to Tektronix' Telequipment line. The new Telequipment D1015 and D1016 Oscilloscopes feature dual trace operation; automatic, normal, and TV triggering; volts/division ranges from 5 mV to 20 V; and sweep speeds from 0.2 microseconds to 200 milliseconds/division. A X5 magnifier increases maximum sweep speed to 40 ns/division.

In addition, the D1016 is equipped with these features:

- X5 magnifiers for each vertical channel to extend sensitivity to 1mV/division. Bandwidth is reduced to 4 MHz at this particular setting.
- Separate pushbuttons to invert channel 2, and to add channels 1 and 2, permitting balanced differential input measurement.
- Direct X-Y displays using channel 1 and channel 2.
- Variable uncalibrated sweep control permitting continuously variable sweep rates.

Telequipment products are sold and serviced in the U.S. by selected stocking distributors. For additional information please use the reply card accompanying Tekscope.

7/79 AX-4268

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