Merging High Performance Alphanumerics and Graphics with Fast Computation

A New Cost-Effective Highly Portable Data Comm Tester

Simultaneous X-Y, Y-T Displays Using a 5100 Series Oscilloscope

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Tekscope

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Tekscope

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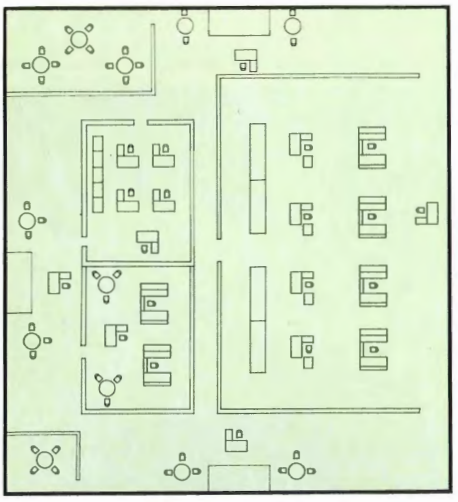
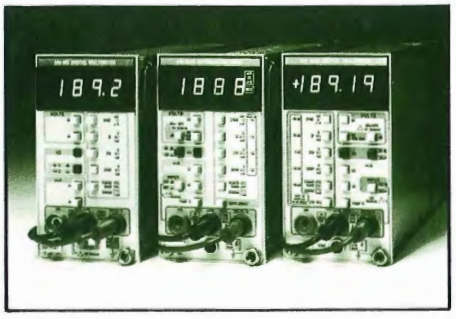
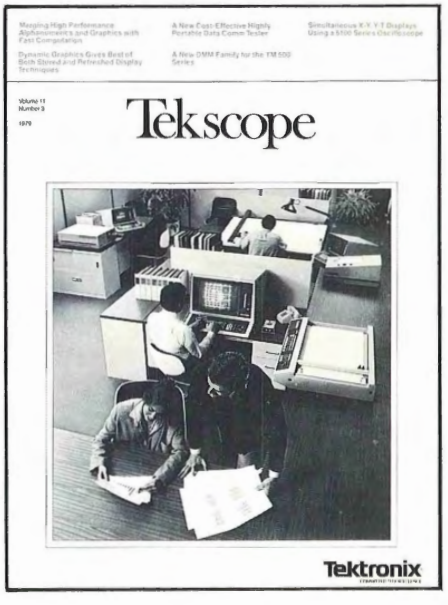
Tekscope is a bimonthly publication of Tektronix, Inc. In it you will find articles covering the entire scope of Tektronix' products. Technical articles discuss what's new in circuit and component design, measurement capability, and measurement technique. A new products section gives a brief description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





COVER: The 4050 Series of desktop graphic computers are equally at home in architectural, electronic, geophysical, or business environments, providing unique solutions to every-day problems.



Merging High Performance Alphanumerics and Graphics with Fast Computation

Dave Barnard joined Tektronix in November of 1976 bringing with him an extensive background in computer and peripheral design. He has been involved in new product introduction and training programs for the 4052, 4054 and 4050 Series ROM Packs. He received a B.S.E.E. from the University of Minnesota in 1965 and an M.B.A. from Claremont Graduate School in 1976. He is currently a 4050 Series Product Specialist. A member of I.E.E.E. and Toastmasters International, he devotes his spare time working with a Boy Scout Troop and to amateur radio satellite communications.

A high rate of market acceptance and need for productivity improvements in the office, laboratory, and in the educational environment for teaching and research, point to one thing: desktop computers are growing in importance and application.

When Tektronix announced the 4051 in 1975, exciting new levels of computing power were available, either in small packages called desktop calculators or in the form of microcomputers whose language and operation required more extensive computer knowledge than was desirable for a user who wanted merely to get his analysis done.

The 4051, with graphically enhanced BASIC, brought problem solving to the desktop in the office or laboratory, with easy operation and graphics to make the results of analysis very visible.

The new 4052 and 4054 provide multi-dimensional enhancements to the features found in the 4051. These new members of the family enhance graphics, alphanumerics, and computing capabilities, by advancing the state of desktop computing to a new level.

Compatibility provides upward mobility

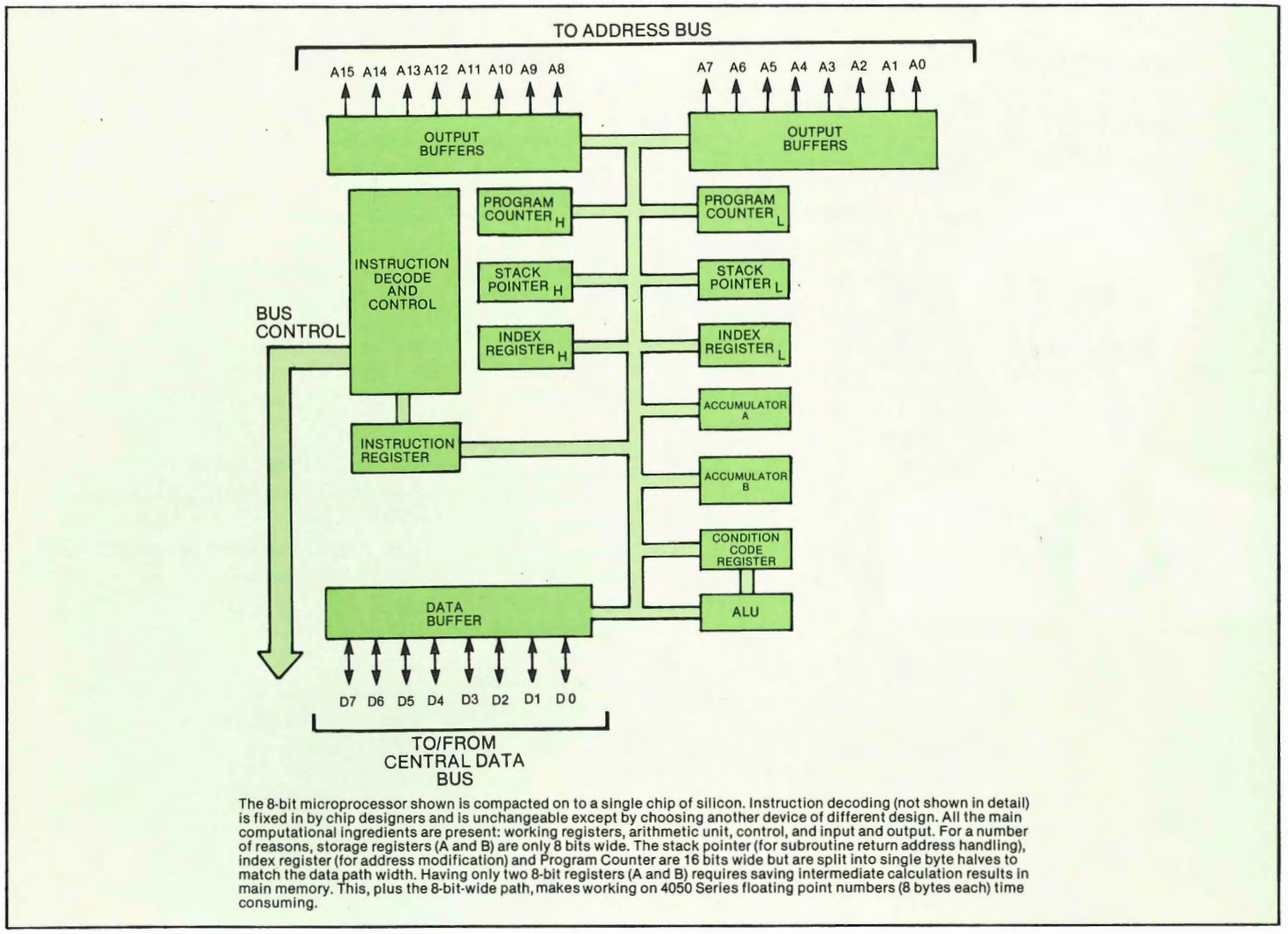
The primary goal in developing the new products was to enlarge the 4050 Series making it a family permitting both existing and new customers a greater choice of capability. Thus, the 4052 and 4054 were designed with compatibility as a major requirement. All three members of the family are completely software, data tape-, and disc-compatible. A customer having a 4051 can move up to a 4052 or 4054 without having to convert programs or data to a new format. Similarly, TEKTRONIX Plot 50 Software products and Application programs will operate on any of the 4050 Series desktop computers.

Performance enhancements

Compared with the 4051, the 4052 and 4054 provide:

- An order of magnitude faster (10X average) computation.
- Larger memory (32k bytes standard) expandable to 64k bytes (56k bytes usable).
- Speed enhancements to graphing using MOVE, DRAW extensions to 4050 BASIC.

Fig. 1. The 4052 desktop graphic computer provides a new dimension in speed, memory capacity and simple utility.



The 8-bit microprocessor shown is compacted on to a single chip of silicon. Instruction decoding (not shown in detail) is fixed in by chip designers and is unchangeable except by choosing another device of different design. All the main computational ingredients are present: working registers, arithmetic unit, control, and input and output. For a number of reasons, storage registers (A and B) are only 8 bits wide. The stack pointer (for subroutine return address handling), index register (for address modification) and Program Counter are 16 bits wide but are split into single byte halves to match the data path width. Having only two 8-bit registers (A and B) requires saving intermediate calculation results in main memory. This, plus the 8-bit-wide path, makes working on 4050 Series floating point numbers (8 bytes each) time consuming.

Fig. 2. Block diagram of the 6800 type microprocessor used in the 4051 desktop graphic computer.

- Faster transfer of data via the option 1 (RS232) and GPIB (IEEE-488 Std. 1975) standard bus.

In addition, the 4054 provides still greater capability:

- Large screen — 19″ display with 13 million addressable points (16 times the 4051 or 4052 display).
- Improved alphanumerics — four character sizes and stroke generated characters.
- Faster, constant rate, vector generator.
- Ability to include Dynamic Graphics — non-stored displays of objects and alphanumerics.

A new multi-chip bit-sliced architecture processor

Achieving the design goals of compatibility with 4051 programs and data structures while enhancing performance was a challenge met by engineering an all new processor.

The most important choice in the new design was the choice of technology for the heart of the processor. The choice — a bit-sliced architecture of bipolar Shottky devices — offers several advantages:

- Modularity, allowing construction of processor word lengths in multiples of 4 bits (e.g., 4, 8, 12, 16 bits). This technique provides improvements in speed and accuracy.
- High density of functions without speed/performance sacrifices, leading to a simpler and faster design than would otherwise have been possible. Simplified design also enhances reliability.
- Microprogrammed design instruction set flexibility that allowed Tektronix to custom tailor the processor and its repertoire of actions (instructions) to suit problem solving with 4050 BASIC and graphics. In other words, the flexibility permitted an efficient processor (does things fast and well) to be made *effective* (does only the things needed and desired) from a user's point of view.

A tailored instruction set

To facilitate compatibility, the new processor's instructions are a hybrid of 16-bit minicomputer and "typical" one-chip microprocessor types.

The 8-bit-wide data path of the 4051 processor is a natural consequence of implementing a very compact and functional design. The new 4052 and 4054 had to appear to be equally comfortable with either 8-bit byte (character) operations or with 16-bit (two characters worth) operations. The character orientation of memory is apparent to a 4050 Series user when working with alphanumeric strings or when saving or reviewing program or data files.

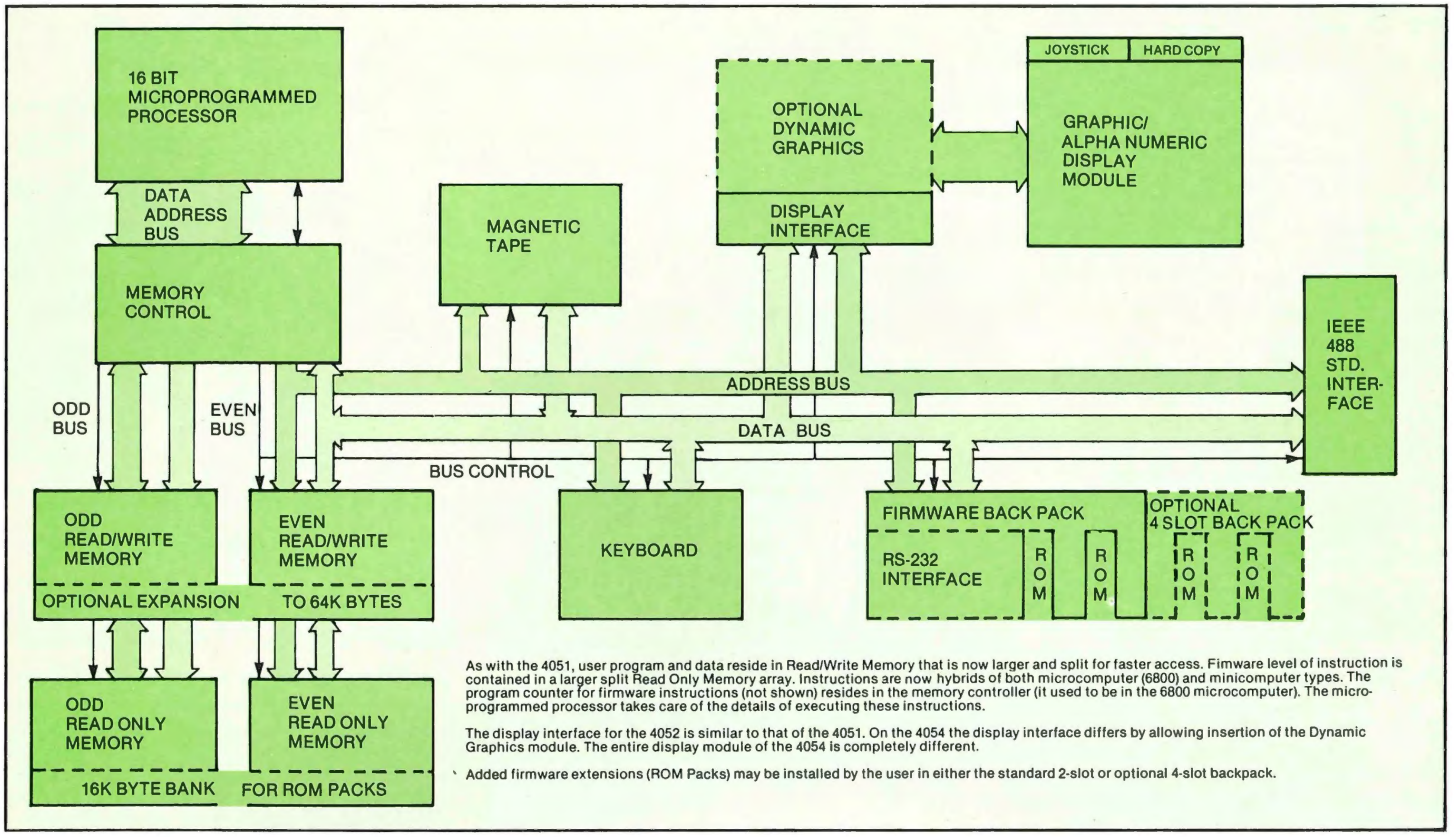


Fig. 3. Simplifed block diagram of the 4052 graphic computer system.

Compatible operations are provided by a new memory design for the 4052 and 4054. Memory is split into even and odd address sections with each on its own data bus. This may seem to be an insignificant detail. However, from the point of view of someone writing or running a program, splitting the memory into even and odd halves allows it to look like 4051 memory. The MEM and SPA commands return quantities of bytes just as with the 4051. Data is READ, INPUT, PRINTed; programs are OLDed, APPENDed, and SAVEd in 8-bit bytes compatible with 4051 operations. But the result of the split memory and faster odd/even busses is to present to the processor the ability to gather twice the number of bits simultaneously. The memory and bus organization are designed to match the 16-bit processor. Thus, compatible operation is provided without compromising performance enhancement.

Added instructions were developed for highly accurate floating point arithmetic operations. These new instructions (coupled with the memory design and faster processor) make complex calculations, such as sine, cosine, and tangent, thirty to forty times faster than with the 4051. The microprocessor of the 4051 has no floating point instructions to help with such complex calculations.

The results of the new processor and the technology choice are faster processing as calculations grow more burdening, simplicity for reliability, and complete compatibility to enable use with existing user and Tektronix written software.

Graphing improvements

Improvements in graphing also are realized. Graphic enhancements to BASIC — the MOVE, DRAW, RMOVE, RDRAW and AXES commands — allow graphics in the user's units, not machine or raster units. The arithmetic of converting user-familiar units to screen units is done by the processor with its own floating point arithmetic commands. This makes graphics, using the 4050 BASIC commands, five to six times faster on the 4052, even though the 4052 uses the same display module as the 4051.

4054 provides enhanced graphics and alphanumerics

The 4054 has greater graphics capability than any other desktop computer. Its larger screen, with 4096 x 4096 addressable points, allows displaying many sets of curves, objects, maps, or business data in great detail.

However, more than just screen size and addressable points have been increased. The display electronics supports the larger viewing area by providing a faster writing rate at a constant 15,000 centimeters per second.

Unlike the display portions of the 4052 and 4051, which use a constant time (4-6 ms) per vector, the new 4054 display draws at a fast, but constant, rate. The maximum length vector, a diagonal 48.2 centimeters long, is drawn in under 4 milliseconds. This is faster than the 4052 and 4051 with either their longest or shortest vector.

Without a faster writing rate, the large screen display would have become a system bottleneck while drawing complex schematics, maps, or mechanical or structural designs. In the 4054, high density graphics is provided

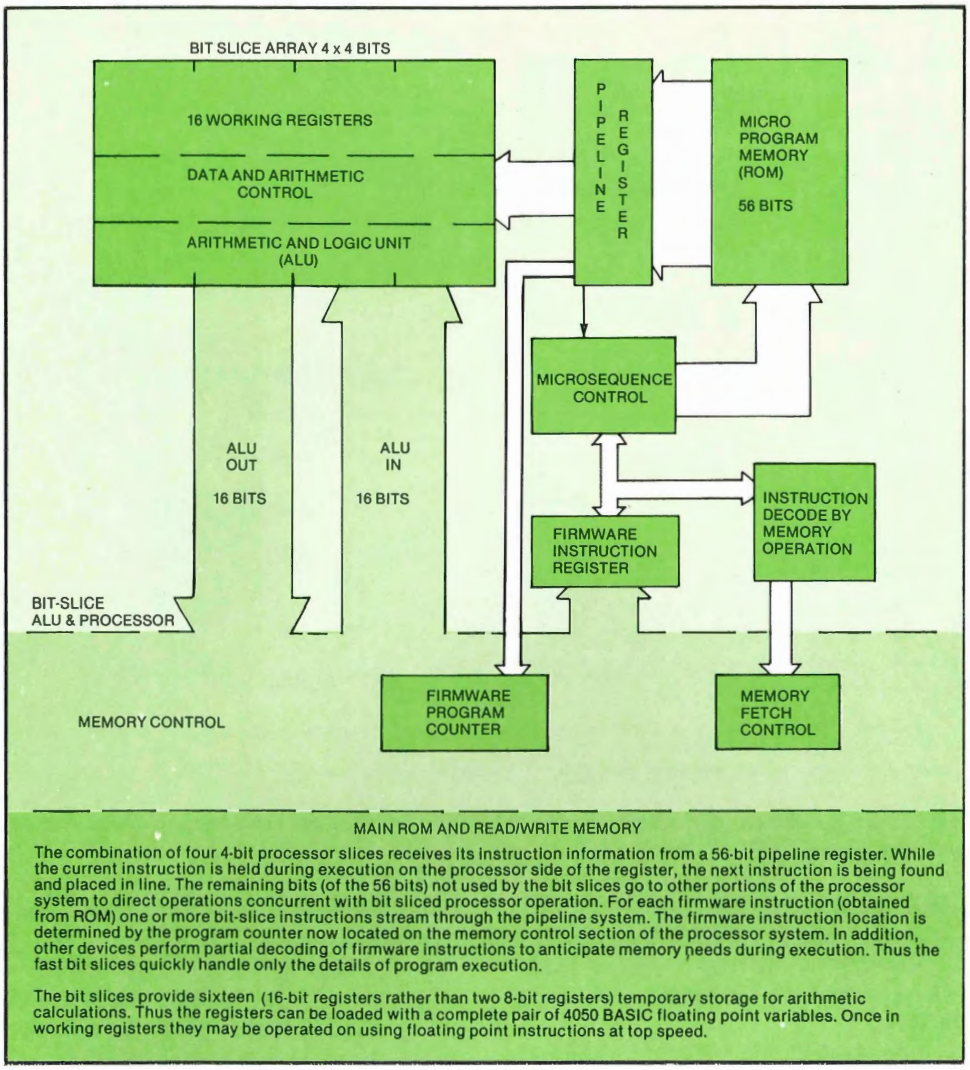


Fig. 4. The bit-sized architecture of the processor used in the 4052 and 4054 provides improvements in speed and accuracy.

with the support it needs to make it truly useful.

An optional feature, Dynamic Graphics, adds refresh capability to the 4054 for even greater flexibility and interactivity. This option is discussed in detail elsewhere in this issue.

Enhanced alphanumerics

The enhancement of alphanumeric displays is equally significant in the 4054. All characters are stroke generated for crisper hard copies. The 4051 and 4052 offer one character size — the 4054 has four. Labeling graphs or large amounts of columnar data is improved, with larger character sizes for labels. The smallest character size on the 4054 is approximately the same as the size of 4052 or 4051 characters. With this character size an entire 64 lines of 132 column print-out can be placed on the screen. When using the 4054 as a terminal (with Option 1) it provides a split screen view of 128 lines of program listing.

When different sets of data are combined on a single graph, as in graphs of actual versus forecasted sales, the hardware dash-dot vectors (36 of them visibly unique) allow distinguishing one set of data from another. Mechanical engineering applications can use the dashes for hidden lines, and different character sizes for title blocks.

The 4054 can help automate the drawing process. Like all other 4050 Series graphics systems, it allows easy mixing of alphanumerics and graphics in the same natural way that hand drawing presents information.

The 4052 and 4051 have a cursor (blinking arrow) which can be moved around the screen to select from a menu or pick a data point on a curve. Moving the cursor requires an optional joystick (or defining the User Definable Keys as "direction keys"). The 4054 has built-in thumbwheels for cursor positioning. The cursor is a full-screen crosshair cursor more useful in some mechanical and other engineering design applications because it is easier to line up objects along rectangular grid lines.

Summary

The new features and enhancements added to the 4050 Series by the 4052 and 4054 are intended to serve a simple but useful purpose — to provide Tektronix customers a wider performance choice of easy-to-use desktop graphic computers which will enrich their productivity by providing timely, easy-to-perceive solutions.

Dynamic Graphics Gives Best of Both Stored and Refreshed Display Techniques

Miki Tokola joined Tektronix in April of 1978 and has been heavily involved in U.S. and International new product introduction programs and training for the 4052 and 4054 Graphic Computing Systems. He has a B.S.E.E. and B.S. in Psychology, both received from the University of Washington in 1973. After three years as a scientific programmer/analyst, he returned to the University of Washington and received his M.B.A. in 1978. He is currently the 4050 Series Product Line Manager. Miki built his own house last summer and devotes his spare time to reading, guitar playing and family activities.

The bistable direct view storage cathode ray tube (DVST) permits the storing and display of complex mixed graphics and alphanumeric images at low cost. By storing high density graphics and alphanumerics on its specially processed screen, the DVST circumvents the need for and cost of the memory system required for refreshed displays.

Without the need for large amounts of memory, meaningful displays of information, interactive complex designs of objects in mechanical design, and building layouts are all possible at lower cost. The stored display technique is used on the 4051, 4052, and 4054 Graphic Desktop Computers.

Standard on all three product displays is a single character of non-stored display. The page full blinking "F" indicator, the cursor, and the blinking "?" that appear in response to a 4050 BASIC program request for keyboard input are all non-stored, single-object displays. These single objects are provided to prompt the programmer or user of the products, via the screen, without cluttering the screen. The Dynamic Graphics option for the 4054 makes these and many other non-storable objects programmable. In fact it does much more.

Dynamic Graphics expands 4054 flexibility and interactivity

The Dynamic Graphics option (4054 Option 30) adds new BASIC commands, and object storage memory to hold objects created with its new 4050 BASIC commands.

Objects, user-defined collections of vectors and/or alphanumerics can be created, displayed, and moved to any position on the screen without being stored, unless or until storage is desired. It's almost like having a superimposed second screen. Use the storage mode as a usual screen display. Use Dynamic Graphics for creating and moving objects without affecting the stored display.

When developing a schematic office layout, architectural, or other drawing, the portions that are completed can be stored on the 19" diagonal screen. By using the Dynamic Graphics option, symbols and lines can be drawn interactively, without storage, superimposed on the same screen. Objects can be selected from a menu (also displayed non-stored), moved around, tried in various positions, and then fixed (stored) when it's desirable to add them to the completed portion of the display.

Objects may also consist of alphanumeric lines to allow placing operating instructions on the screen without cluttering the display. When an operator prompt message is no longer needed, it is deleted from the screen without having to erase and redraw the entire display.

An interactive example

Let's examine an office layout application closely and see how the 4054 with Dynamic Graphics provides an efficient solution to the design problem. To begin, a menu in refresh is displayed in the upper left corner of the screen, explaining the functions of the User Definable keys.

First, the designer draws the exterior walls of the office. Pressing one of the User Definable keys brings up the cross-hair cursor. Using the cursor and the thumbwheels, the designer defines the corner points of the walls and doors. Once the walls are placed, the menu is returned by pressing a User Definable key. Notice that the menu can be recalled and erased independently with Dynamic Graphics. It is no longer necessary to erase the entire screen to eliminate the menu.

Next, desks are arranged. A User Definable key brings up a menu of desks and other office furniture at the bottom of the screen. After the appropriate object (in this instance a desk) is chosen, it is moved around the screen using the thumbwheels. The desk can be tried in different places in the office; when the deisred location is found, an image of the desk is stored on the office display with a single keystroke. Successive replicas of the desk can be positioned around the office by moving the object with the thumbwheels and storing copies as the design continues. Similarly, wall partitions, plants, file cabinets, and conference tables are quickly picked from menus, positioned and stored. Once the plan is completed, a 4662 or 4663 Digital Plotter plots the office layout. The procedure is quick, easy, and highly interactive.

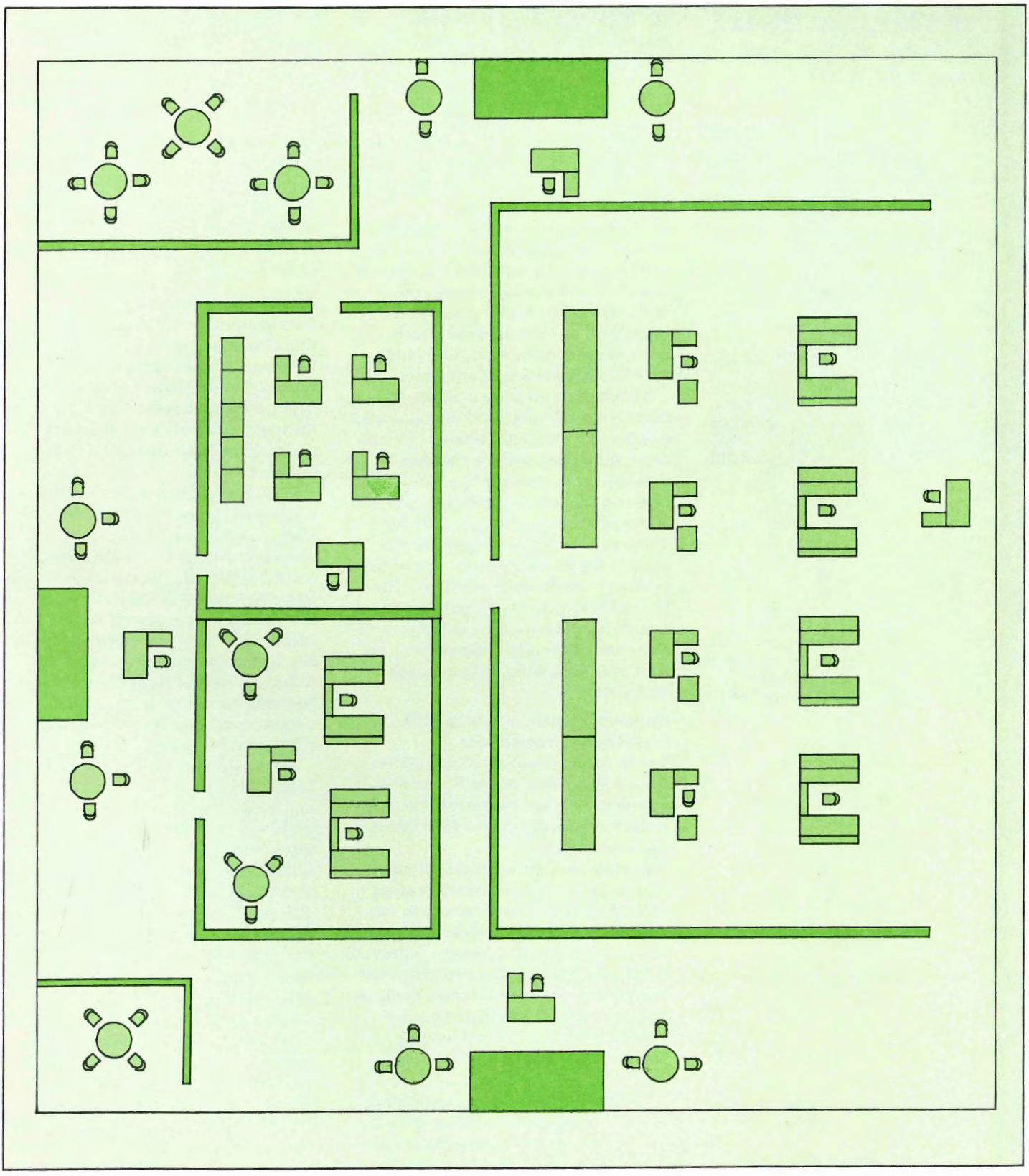


Fig. 1. Dynamic Graphics offers a great speed advantage in applications such as designing office layouts, as illustrated here, where objects stored in dynamic memory are called up and displayed in refresh mode.

Dedicated graphics option adds a dedicated microprocessor

By now you can appreciate not only the power of Dynamic Graphics but also the computing power and memory required to provide this capability.

Dynamic Graphics is a single circuit board installed in the 4054. A high-speed microprocessor and 32 kilobytes of dynamic memory are dedicated to the creation and display of refresh objects, completely independent of the 4054's processor. When Dynamic Graphics commands are received, the microprocessor stores the objects created in its own memory. Timing circuits prompt the Dynamic Graphics option to retrace its display memory, producing non-stored images on the screen.

The number of vectors displayed without flicker depends on the length of the vectors. Up to 1,000 vectors averaging one-half centimeter in length may be displayed without flicker. The amount of displayable text is related to the number of strokes in each character. At least one full line of text, or several shorter lines, can be displayed in refresh mode.

New commands

New language commands facilitate writing BASIC language programs to create objects. The object can be any meaningful unit: a simple line or word, a complex 1,000 vector object, or a program menu. An ROPEN statement begins the construction process; subsequent vectors and text strings define the object. The definition continues until an RCLOSE statement is encountered. An RAPPEND command will expand the definition. The specified object is reopened to add additional vectors and/or text. Object definitions can also be deleted or replaced.

The object definitions, along with some display information automatically provided by the 4054, are stored in the Dynamic Graphics memory. This separate memory permits efficient object storage which doesn't subtract from the 4054's read/write memory. It's easy to build a large set of objects.

An object appears on the 4054 screen through the VISIBILITY command. This command causes the object's definition to be repeatedly retraced (refreshed), producing a non-stored image on the screen. The displayed image of the object can just as easily be deleted; the image no longer refreshed vanishes from the screen. However, the definition remains in dynamic memory. This allows interactive prompts and program responses without cluttering the screen with unneccessary text.

A BLINK command alternates an object between visible and invisible modes according to user-specified on and off times. It can be used to draw the operator's attention to a prompt or indicate an object needing some user action.

Motion is another major graphic enhancement. The refreshed image of the object can be moved around the screen either under program control interactively with the thumbwheels, or by using an optional graphic input device such as a graphic tablet or joystick. The CURSOR command replaces the standard cross-hair cursor with a specified object and places it under direct control of the thumbwheels.

The FIX command copies the object onto the screen in storage mode. You can quickly place multiple images of an object by repeatedly positioning and fixing the object. There is a great speed advantage with Dynamic Graphics. An object stored in the dynamic memory can be displayed on the screen up to 100 times faster than by drawing it directly from a program onto the screen.

No compromise in compatibility

Language compatibility, a major feature of the 4050 Series, is maintained. The new commands are ignored by the 4052, and by 4054s without the option. Special provisions to interact with optional graphic input devices, such as the joystick or graphics tablet, have been incorporated.

New application for graphics

This refresh capability also provides real-time simulations. With the CURSOR command, it is possible to replace the cross-hair cursor with any refreshed object and place the object under the control of the thumbwheels. Imagine a 4054 with Dynamic Graphics as a tactical decision aid. A submarine is created and becomes the cursor. A second object, a destroyer, can be displayed in refresh and its position determined by the location of the submarine. It is now possible to simulate evasive maneuvers by allowing the operator to move the submarine around the screen, trying to avoid detection by the destroyer.

To be useful — tools must fit their uses

In designing, you often think in terms of standard graphic components, such as a desk in facilities layout, or a transistor symbol in a circuit diagram. Dynamic Graphics provides the graphic power to work directly with these graphic elements, not just points or lines.

The examples we've chosen can only hint at the power of 4054 Option 30 Dynamic Graphics. We know that users will apply this increased graphic interactivity in many creative ways.

The 4054 has the most powerful graphics feature available in a desktop computer. With the addition of Dynamic Graphics, the potential application areas are greatly expanded.

A New Cost-Effective Highly Portable Data Comm Tester

Art Yerkes is a relative newcomer to Tek having started with the Digital Service Instruments Group in 1978. After receiving his B.S. in Electronics Physics from LaSalle College in 1974, he worked for Datapro Research, an organization that provides a computer product reference service, a type of consumer's guide of the computer industry. Much of Art's digital communications background involved working with stock market information systems. He is presently engaged in marketing activities for Digital Service Instruments.

When problems strike a data communications system, fast, effective service is a must. For example, there are networks in existence where cost for down time extends into tens of thousands of dollars per hour. The TEKTRONIX 833 Data Comm Tester is designed for just such a function. Typically, a service technician, using the 833, should be able to locate and correct over eighty percent of the troubles on first call. The remaining ten to twenty percent will probably require an expert on the data comm system, and more sophisticated, expensive test equipment.

The 833 is a "friendly" instrument — easy to learn, easy to operate, and easy to carry. It weighs just twelve pounds. Applicable to any RS232-C, C.C.I.T.T. V.24, or current loop interface, the 833 can monitor or apply test signals to and from the modem (DCE) or the data terminal equipment (DTE). It can also be used to evaluate the quality of the data link. Microprocessor control gives the 833 unusual versatility and, at the same time, reduces the number of front panel controls needed to effectively use that versatility.

A perusal of the front panel shown in figure 2 provides an overview of the many operating configurations available with the 833. Note that in addition to working with synchronous and asynchronous systems, the 833 accommodates systems using the HDLC protocol and employing standard or NRZI data encoding schemes.

A wide choice of data rates is provided. Baud rates from 50 to 9600 bits per second are available from an internal clock, or you can select a supplied clock from the host computer, data terminal, or communications equipment. Provision is also made to derive the clock from the data stream.

The 833 can operate in full duplex or half duplex mode with turn-around delay in half duplex selectable from the keypad. The keypad plays an important role in 833 operations. It allows you to program the instrument specifically for the network under test, e.g., selecting character length, synchronizing signals, etc. The keypad also serves as mode and buffer selector.

Operating modes

The versatility of the 833 is evidenced by the wide choice of operating modes provided. In the MONITOR mode, data transmissions in both directions are displayed in real time and recorded. The portion recorded is determined by the START, STOP, and MEMORY CONTROL controls. You can choose to display DCE or DTE data, or both. Both are recorded and maintained irrespective of which is selected for display. The source of the displayed data, and the status of the interface lines are also recorded and displayed along with the data and its location in memory.

In testing data terminals and DCEs, the SIMULATE, ECHO and REPEAT modes are used. Regular SIMULATE

Fig. 1. The highly portable 833 Data Comm Tester

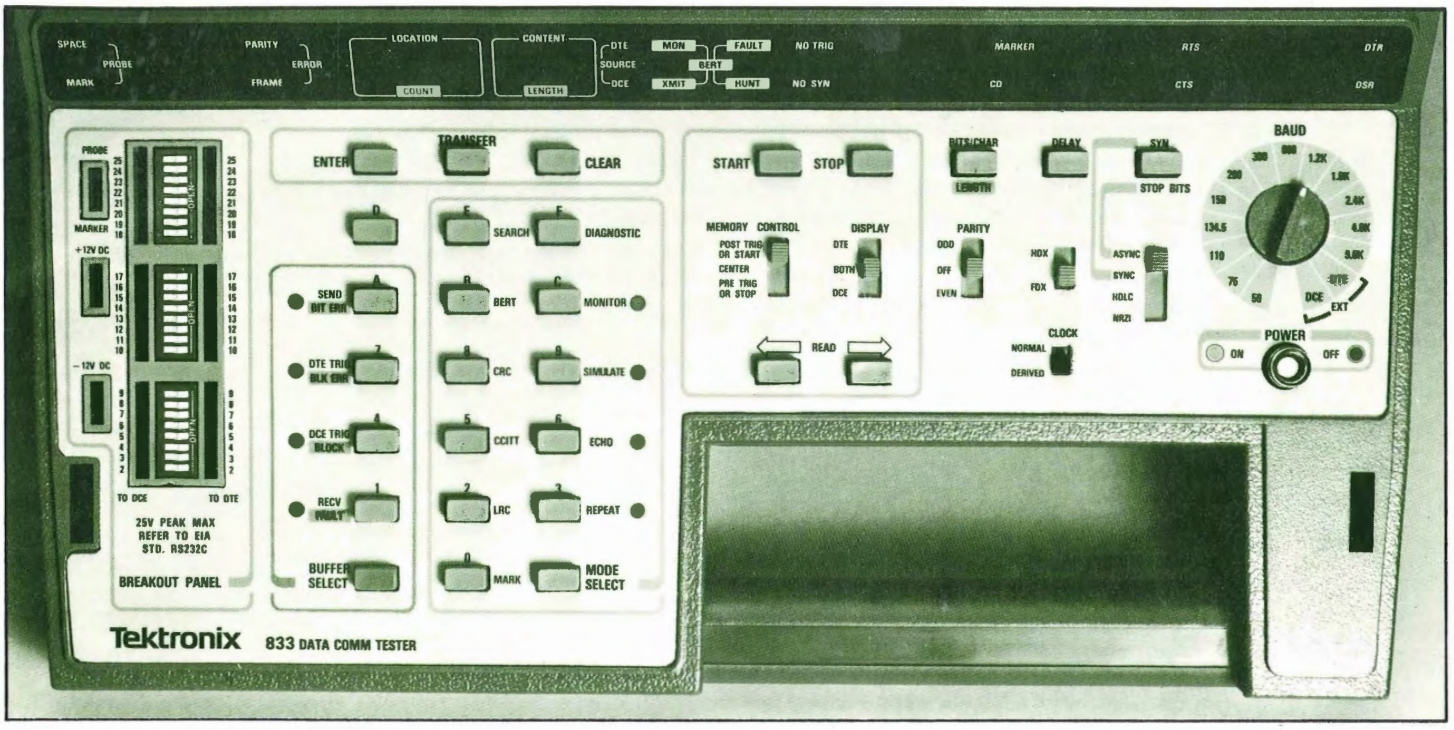


Fig. 2. The many operating configurations available to the 833 user are easily discerned from the functional front-panel layout.

mode transmits a message once and records the response. REPEAT mode transmits a message repeatedly, recording any interleaved responses. And ECHO mode performs as the regular simulate mode but, in addition, echos received characters back to the transmitting device. Trigger sequences may be used with any of the simulation or monitoring modes to achieve a variety of specialized tests.

A message can be entered from the keypad, or you can select one from several stored in ROM. Messages in ROM include an ASCII fox test, upper case ASCII characters, a full ASCII character set, a set of 132 upper case ASCII characters, an EBCDIC fox test, and upper case EBCDIC characters. There is also provision for a user-defined message PROM with a capacity of 2048 bytes.

The SEARCH mode provides a convenient means of searching both the send and receive buffers for the presence of data sequences of from one to three characters. The trigger buffer is used to hold the specified characters.

Extensive self test

As you work with communications systems it is important to know that your test instrument is working properly. The 833 performs a self-test on power up. A RAM march test, RAM bit independent check, and a ROM check sum test are performed, and all of the LED readouts are energized.

In addition to the start-up tests, the 833 can be put in the DIAGNOSTIC mode and a number of extensive test routines called up from the keypad. These include a more thorough test of memory, the display elements, slide switches, pushbuttons, baud switch, CPU, and other elements.

CRC calculation

Communication systems differ in the scheme used to detect errors in data handling. The 833 calculates three kinds of message check bytes: CRC-16, CRC-CCITT, and LRC-8. CRC, or cyclic redundancy check, is most commonly performed on bisynchronous messages that use EBCDIC code. CRC-CCITT is another form of CRC that is commonly used on systems with HDLC protocol. LRC-8, or longitudinal redundancy check, is still another form of check character in which a parity check across the whole message is performed. It is commonly encountered in bisynchronous systems that use ASCII code.

CRC characters are numbers generated by using message data as a very long binary number and performing a mathematical operation on it. The MARK key is used to select the character marking the start of each CRC calculation. The user selects the end character for the calculation by stepping through the buffer until the desired character appears in the readout. The CRC calculation is then initiated by pressing the appropriate CRC key, followed by MODE. Results of the tests are displayed in the LOCATION and CONTENTS section of the display.

BERT testing

It is sometimes useful to check the quality of the data line itself, and the most common method of doing that is to perform bit error rate testing, or BERT. The 833 provides this capability. The CCITT BERT pattern is a 511-bit message sent and read on a looped-back

line, or sent to a receiving BERT tester on the other end, so that errors may be counted. The 833 will perform three different test lengths — 100,000 bits, 1,000,000 bits, or continuous. In the continuous mode, the test is run until 999 bit errors are counted or until the STOP key is pressed. The results of the test reside in several registers. You can choose to read the bit error rate (which is displayed real time during the test), the number of 1000-bit blocks received, the block error rate, or the number of faults. A fault is recorded each time the error rate exceeds twenty five percent over a span of sixty-four characters. Errors may be injected into a transmitted bit stream, and you may clear all registers during the test, if desired.

Buffer selection should be an integral part of the operating mode discussion. There are four selectable buffers: SEND, DTE TRIG, DCE TRIG, and RECV. These also serve an alternate function in BERT operation. The send and receive buffers will hold 255 and 256 characters, respectively. The trigger buffers hold three characters.

Messages can be entered into the SEND, DCE, or DTE buffers from the keypad. Messages stored in any buffer, including the receive buffer, stored message buffers, or user-defined message buffers (EPROM) can be transferred to the SEND buffer. The transfer action does not destroy the contents of the buffer transferred. The receiver buffer is automatically cleared when the START button is pressed, and records whenever a trigger occurs or the STOP button is pressed.

The EPROM capabilities provide users the ability to construct a fairly large set of messages specific to their needs, and use them in a manner which makes it appear as if they were factory installed, e.g., with no complication of the user interface.

The interface breakout panel

The interface breakout panel on the front panel of the 833 is an important troubleshooting aid. It provides direct access to the interface lines. Twenty-four line disconnect switches are used to control throughput to and from the data terminal or data communication equipment. Patch pins, electrically connected to each side of the disconnect switches, provide easy access to any line.

Also included in the breakout panel are jumper pins for the probe and marker LEDs, and for the −12 volt and +12 volt reference supplies. You can open any line using the breakout switch, or cross-connect lines using supplied jumper wires between the patch pins. The probe LED circuit can also be patched to any line; or, if you want the signal recorded, you can patch to the marker LED circuit. Any of the lines can be forced HI or LO by patching to one of the reference supplies.

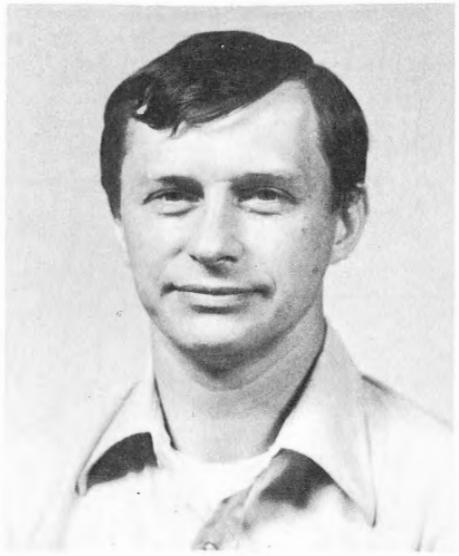
A simplified display

In selecting the type of display to be used in the 833 many factors were considered — the kind of information to be viewed, the space required, weight, and cost being the major factors. Digital information is presented by two 7-segment LED readouts — one a three digit and the other a two digit. The two digit display presents data in hexadecimal format. This simplifies the display and eliminates the need for memory space for special ROMs for the different code sets. The three digit display is used to show the location of the data in memory, and for other functions. Other LEDs are used to indicate the source of data, parity and framing errors, trigger and sync status, and the status of the interface lines. Two LEDs provide a built-in logic probe function that can be connected to any interface line (at the breakout panel) to show its logic level in real time. The MARKER LED serves a similar function but differs from the PROBE LEDs in that the status is recorded along with each character.

Summary

The 833 is designed to provide a cost-effective solution to the problem of servicing data communication systems in a fast, efficient manner. It can monitor data flow in both directions and allow you to analyze that data; simulate the modem, poll multi-terminal systems, and perform BERT testing to check the quality of the data link. These and many other tasks can be performed on an instrument which is easy to learn, easy to operate, and easy to carry to the site of the next problem.

A New DMM Family for the TM 500 Series



Bill Mark joined Tek in 1968 after completing his B.S. in Electrical Engineering Technology at Weber State College in Utah. He received his B.S.E.E. from the University of Portland in 1978. Bill worked with the Product Evaluation group doing electrical evaluation on accessories and general purpose instruments. He also did high-impedance attenuator design for some of the 400 Series Oscilloscopes. He is responsible for the electrical design of the DM 501A.

Bill is an amateur mycologist (one who can discern between palatable and poisonous mushrooms) and enjoys gardening, hunting, and fishing.

The capability to assemble an instrumentation system tailored to your application is one of the major benefits offered by the TEKTRONIX TM 500 Series. Now, three new digital multimeters — the DM 501A, DM 502A, and DM 505 expand this capability substantially.

In designing these additions to the TM 500 family, the major goals were to improve reliability, increase display size, expand measurement ranges, improve accuracy, enhance operating ease, and provide a wider choice of measurement capability. All of these goals have been achieved.

The DM 501A and DM 502A replace their earlier counterparts, the DM 501 and DM 502, respectively, while the DM 505 is a new addition to the family.

The DM 501A and DM 502A are seven-function multimeters, including dc and true rms ac voltage and current measurement, HI-LO resistance, decibels (dBm and dBV), and temperature. The DM 501A features 4 ½ digit readout with 10 μV resolution and 0.05% dc voltage accuracy.

The DM 502A adds the convenience of autoranging for all but current measurements and provides 3 ½ digit readout with 100 μV resolution and 0.1% accuracy for dc voltage.

True rms measurements

True rms ac measurement is a new capability for the TM 500 Series DMMs. Both the DM 501A and DM 502A use the technique of rectifying the input waveform, squaring it, filtering it over several cycles, and then taking the square root of it. This approach results in a true rms reading for any input waveform within the bandwidth and crest factor limitation of the DMM. The DM 501A and DM 502A have a crest factor of 4.

Many applications, such as measurements on regulators, power control circuitry, etc., involve signals other than sinewaves which can only be measured accurately with a true rms meter. White noise, two-tone intermodulation test signals, and other communications signal measurements also require true rms for accuracy.

The DM 502A couples true rms dB measurement with autoranging capability to provide unprecedented operating ease for communication and audio measurements. Autoranging eliminates the traditional need for range changing and addition of the display reading to the range setting for computing the final value. If the test signal source is a TM 500 plug-in, the ability to switch between rear and front panel inputs speeds up gain measurements still further.

Unexcelled temperature measurement

A new temperature probe, the P6601, provides the DM 501A with the widest temperature measurement range of any DMM available today (−62° to +240°C). Temperature measurement with the DM 502A is −55° to +200°C.

The P6601 uses a thin-film platinum resistor mounted on a silicon substrate, as the sensing element. This is bonded to a hemispherical beryllium oxide tip for contact with the outside world.

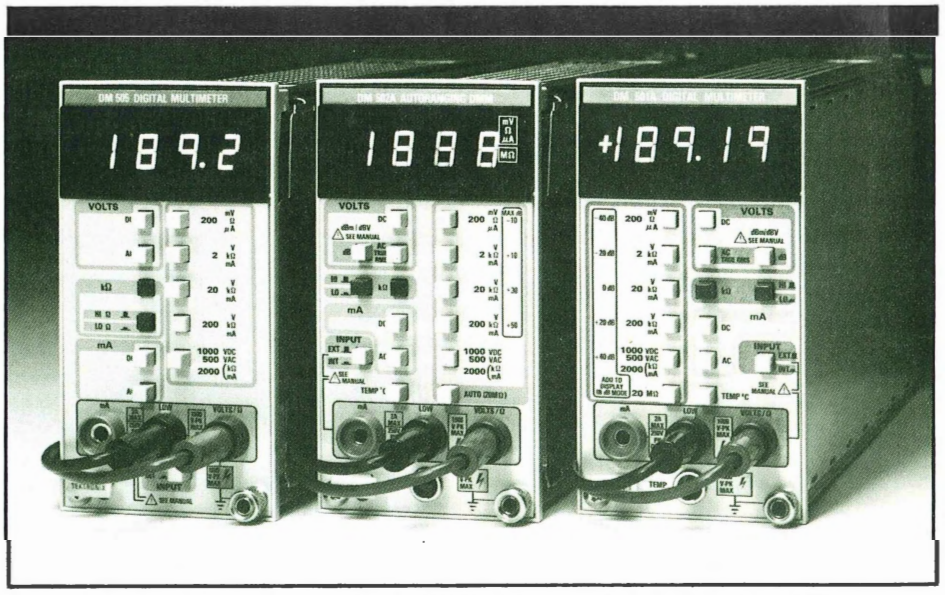


Fig. 1. Three new digital multimeters greatly expand the range of measurement capability available to TM 500 users.

Electrical contact with the sensor is via fine wire bonding leads. The entire mass is very small which results in minimum heat sinking of the object to be measured, and a rapid response time (0.5 seconds ±0.2 seconds). The dome-shaped tip reduces the amount of surface contact and eliminates the need for a thermal compound (silicon grease) and precise probe positioning. Combined heat sinking and thermal gradient errors for common transistor cases is shown in figure 2. The high temperature probe body and cable design of the P6601 permits immersion in liquids or use in temperature chambers at temperatures up to +140°C.

There are no calibration ajustments on the probe assembly. Any necessary adjustment is done in the DM 501A and DM 502A which contain the probe amplifier and linearization circuitry.

A new low cost member

The DM 505 is a 5-function DMM designed for the many applications best met by an inexpensive, easy-to-operate dependable digital multimeter. Education and production uses are typical examples. Functions include dc and ac voltage and current, and HI-LO resistance measurements. The ac voltage function is average responding, rms calibrated, which is a convenience when comparing results with earlier readings taken by average responding meters.

A family resemblance

The DM 501A, DM 502A and DM 505 have much in common. Each features a large, bright, seven-segment LED display, pushbutton range and function selection, floating inputs, and selection of rear and front-panel inputs. Measurement ranges are the same with a few exceptions. The chart in figure 3 provides a quick comparison of characteristics.

Some special considerations

Several areas required intensive effort to meet design goals for performance, buildability, maintainability, and reliability.

Making accurate ac voltage measurements will serve as a typical example. Many printed-circuit boards exhibit a characteristic we call "hook". Hook may be defined as the effect on a signal's voltage amplitude caused by a change in pc-board capacitance with a change in frequency. This capacitance varies inversely with frequency and is most

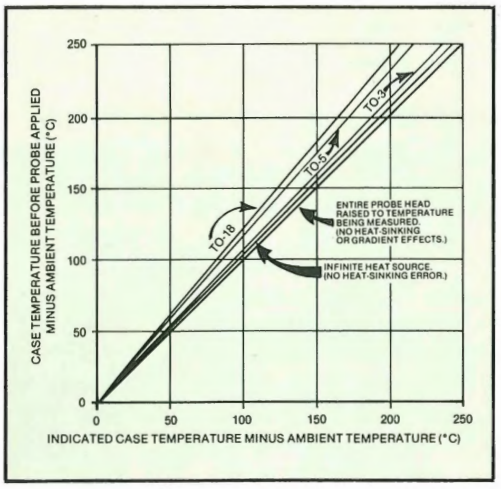


Fig. 2. Combined heat sinking and thermal gradient error introduced by the P6601 when measuring different sized transistor packages.

dominant below 1 to 20 kHz.[1]. In addition to pc board material, dielectrics used in capacitors, switches, and other components were evaluated for hook.

The effect of hook is most troublesome in DMMs in the attenuators used for the ac converter circuitry, where it can introduce measurement errors of 1% or greater. The effect is aggravated in high-humidity environments. Working with our pc-board suppliers we have established standard tests for measuring board capacitance and determining which boards are acceptably hook free. This allows us to use conventional manufacturing techniques and yet hold tight specifications over the entire operating range of 20 Hz to 20 kHz.

Floating input ac measurement is another area which received special attention. The metal plug-in enclosure used for the plug-in modules provides good shielding from external signals but requires the use of guarded shields to eliminate the effects of stray capacitance on floating ac measurements. Both the ac attenuators and input circuitry have guarded shields.

To eliminate undesired coupling between digital and sensitive analog circuitry, a star grounding system was adopted. The star grounding scheme keeps pc board costs low by not requiring the use of multi-layer boards. Ground currents for these different circuits flow through separate ground paths and meet at a common point at the power supply. The points at which various ground currents enter a particular ground return are also carefully selected to prevent generating undesired offset voltages.

Summary

The new family of DMMs for the TM 500 Series is designed to give you a wide choice of measurement capability for your TM 500 measurement system. Extended capability, operating ease, large LED displays, specified accuracies over the entire operating range, and other features allow you to make DMM measurements with greater ease and confidence in the the results.

1 "Getting rid of hook: the hidden pc-board capacitance", Electronics, October 12, 1978.

MODEL NUMBER	NUMBER OF DIGITS	NUMBER OF FUNCTIONS	DC VOLTS			AC VOLTS			AC + DC CURRENT	dB	OHMS (HI-LO)	TEMP	TRUE RMS	AUTO RANGE
			RANGES	ACCURACY	BEST RESOLUTION	RANGES	ACCURACY	BEST RESOLUTION	RANGES	RANGES	RANGES	RANGE		
DM 501A	4½	7	200 mV to 1000V	±0.05%	10 μV	200 mV to 500 V	±0.6%	10 μV	200 μA to 2 A	+54 dB to -60 dB	200 Ω to 20 MΩ	-62 C to +240 C	X	
DM 502A	3½	7	200 mV to 1000 V	±0.1%	100 μV	200 mV to 500 V	±0.6%	100 μV	200 μA to 2 A	+50 dB to -60 dB	200 Ω to 20 MΩ	-55 C to +200 C	X	X
DM 505	3½	5	200 mV to 1000V	±0.1%	100 μV	200 mV to 500 V	±0.5%	100 μV	200 μA to 2 A		200 Ω to 2 MΩ			

Fig. 3. Chart providing rapid comparison of major characteristics of the DM 501A, DM 502A and DM 505.

Simultaneous X-Y, Y-T Displays Using a 5100 Series Oscilloscope

Les Hurlock joined Tek in 1958 and spent several years as Service Center Supervisor in mid-west and West Coast Field Offices. Returning to Portland, he served in Engineering and Training, where he authored several technical publications. Currently, Les is Marketing Product Specialist for 5000 Series products. He is heavily involved in applications for the life sciences market and has authored a number of biomedically-oriented application notes.

Medicine and other scientific fields often call for measuring the relationship between physical forces. By using transducers to convert such forces into electrical signals, an oscilloscope can be used as a convenient and accurate measurement tool.

Many physical measurements made with an oscilloscope involve the relationship between two separate forces, one placed on the vertical (Y) axis and the other on the horizontal (X) axis of the display. Applications occur where one of these forces must also be measured as it progresses through time (T). TEKTRONIX 5100-Series Plug-in Oscilloscopes are ideal for such applications, providing simultaneous X-Y and Y-T displays on a single instrument.

Any single-beam 5100-Series mainframe can be used for such displays. A 5100-Series dual beam mainframe can also be used but will require modification. The set-up uses two single-channel amplifier plug-ins (or two multichannel plug-ins in the single-channel mode) in the left and center compartments, and a 5B12N Dual Time Base Plug-in in the right hand compartment.

The 5B12N controls are set for dual sweep operation with automatic triggering. The A Time/Div control is set to one of the amplifier positions (50 mV or .5 V/div), and the B Time/Div control to the desired sweep speed. The B sweep is triggered internally from the center plug-in.

With the 5B12N operating in the CHOP mode, time base A (now serving as an 'X' amplifier) is paired with the left hand plug-in to produce an X-Y display (top trace of Fig. 1). Time base B is paired with the center plug-in to present a Y-T display (bottom trace of Fig. 1).

The 'X' bandwidth (through the 5B12N) is dc to 1 MHz, while the 'Y' bandwidth depends on the vertical plug-in used. Typically it is 1 or 2 MHz. The X-Y phase shift is not specified when using time bases in the "amplifier" mode; however, it typically will be $\leq 2°$ dc to 100 kHz.

A typical application

As an example of the value of simultaneous X-Y, Y-T displays let's consider a fairly common medical application.

One way to measure human respiratory performance is through the use of an oscilloscope and a wedge spirometer with transducer outputs. Typical measurements include Vital Capacity, Forced

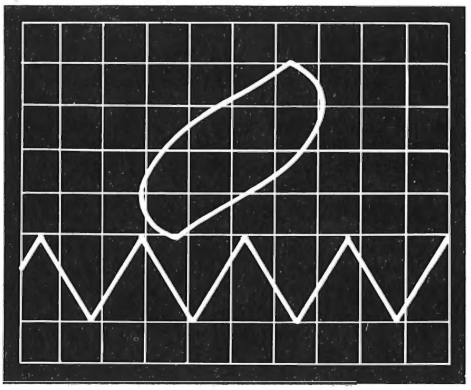


Fig. 1. Combination X-Y, Y-T display.

Expiratory and Inspiratory Volume and related parameters. Usually, each measurement requires a separate effort on the part of both the patient and the test attendant. The 5100-Series simultaneous X-Y, Y-T capability allows two measurements to be made at once, saving both patient effort and lab time.

Since this application requires a permanent record of real-time activity, it is convenient to use a storage oscilloscope and then photograph the resultant display. In this instance, a 5111 Storage Oscilloscope with two 5A15N Amplifier Plug-ins, a 5B12N Dual Time Base, and a C-5B Camera are used.

The wedge spirometer has two outputs — "volume" and "flow" (see Fig. 2). The "volume" output serves as the 'Y' signal and is applied to the inputs of both 5A15 Amplifiers. The "flow" output represents the 'X' signal and is applied to the A Ext. Input connector of the 5B12N.

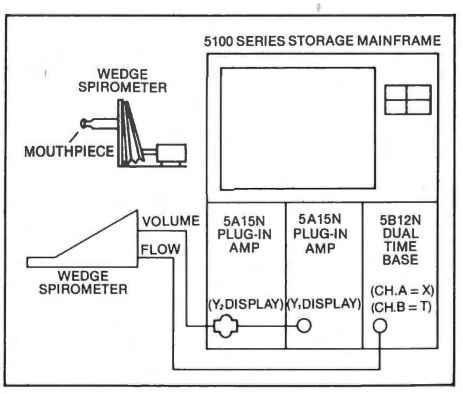


Fig. 2. Diagram of setup which routes the "volume" signal through both left and center amplifiers and represents the "Y" part of both X-Y and Y-T displays.

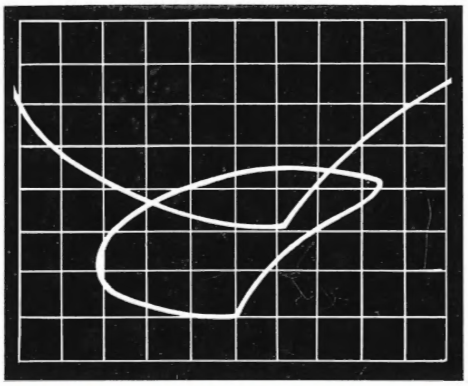


Fig. 3. X-Y display showing flow/volume loop (lower), and Y-T display of volume/time spirogram (upper).

The precise test sequence is determined by qualified medical personnel. Briefly, the patient is instructed to inspire to total lung capacity, blow out forcibly to residual volume, and then inspire rapidly to total lung capacity before taking the mouthpiece out of his mouth.

The resultant scope image will show two displays (Fig. 3). The flow-volume loop is the X-Y display produced by time base channel A (X = flow), and the left amplifier (Y_2 = volume). The volume-time spirogram is the Y-T display produced by the center amplifier (Y_1 = volume) and channel B time base (T).

Summary

TEKTRONIX 5000-Series Plug-in Oscilloscopes provide a wide range of measurement capability with a broad selection of mainframes and plug-ins available. They can operate as general purpose instruments, yet fulfill special measurement needs as in this instance of providing simultaneous X-Y, Y-T displays. Application notes covering this and other applications are available from your Tektronix Field Office or Representative.

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