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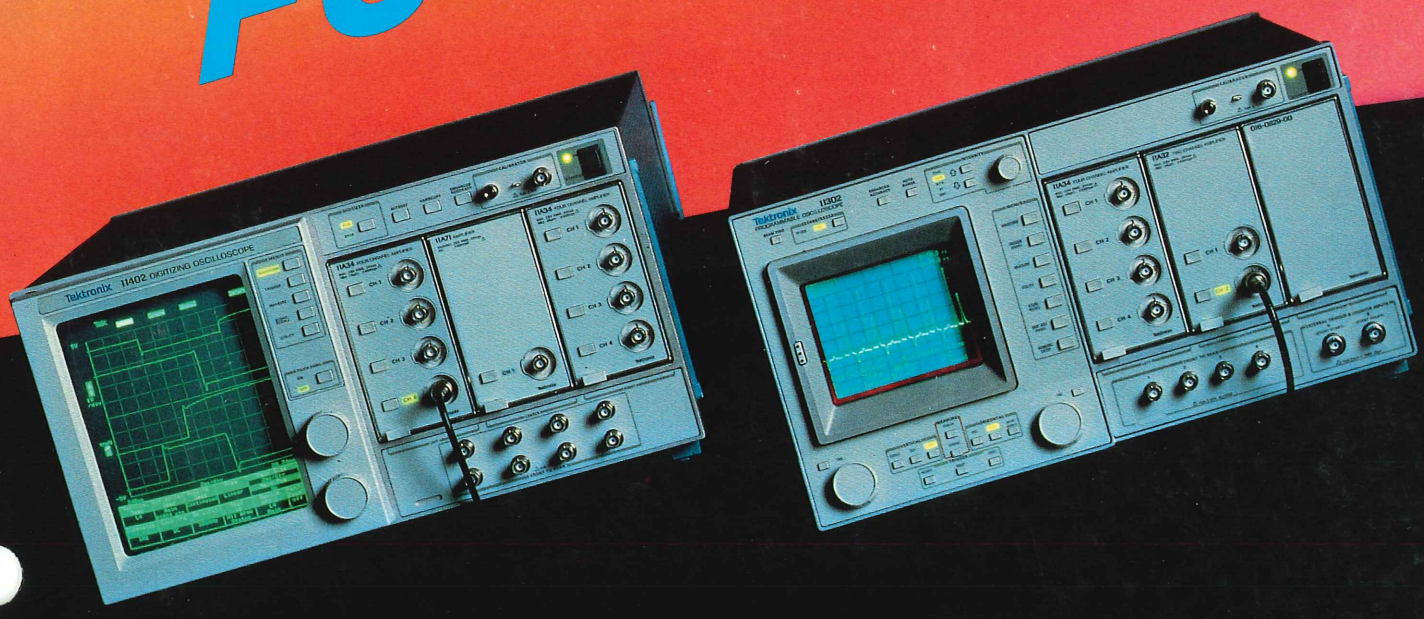
HANDSHAKE

NEWSLETTER OF SIGNAL PROCESSING AND INSTRUMENT CONTROL

A TOUCH OF THE FUTURE



Tektronix
COMMITTED TO EXCELLENCE

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A look inside

Tektronix has long been known for its innovations in the science of making measurements. Through four decades, Tektronix oscilloscopes have set the standards against which all others are measured.

In 1946, Tektronix introduced its first oscilloscope — the Model 511. This was the first commercially available oscilloscope with a time-calibrated, triggered sweep. It quickly became the standard for oscilloscopes the world over.

The 530- and 540-Series introduced the plug-in concept to oscilloscope measurements in 1953. This brought a new standard of measurement accuracy and expandability to oscilloscopes.

1969 marked the introduction of the 7000-Series which brought new measurement convenience through on-screen readout, multiple plug-ins, and many other features. Again, a new standard was created which is still in effect almost 20 years later through the continual addition of new mainframes and plug-ins to add additional capability and continuing value.

Now, we introduce the 11000-Series — the scope for the 80's, 90's, and beyond. In this issue, you'll find articles on the four new mainframes, five new plug-ins, and three new probes which make up the initial offering in the 11000-Family from Tektronix. With a unique touch-screen interface, automatic setup, built-in signal measurements, extended accuracy, and many more features, a new standard is set — oscilloscope measurements will never again be the same. To find out more about these exciting new instruments, you'll want to read all of these articles on the 11000-Family.

We also bring you another application article on materials testing. **Zero defects through automatic ultrasonic testing of nodular iron castings** describes a method of testing cast parts using non-destructive testing techniques. And, as usual, we include introductions for several other new products from Tektronix.

This issue of **HANDSHAKE** contains a lot of information to help solve your signal processing problems. For more information on any of the products described in this issue or for help with other signal measurement needs, contact your local Tektronix Sales Engineer or Tektronix Sales Representative for your country. And be sure to tell them you saw it in **HANDSHAKE!**

A. Dale Aufrecht
HANDSHAKE Editor

Tektronix redefines the oscilloscope

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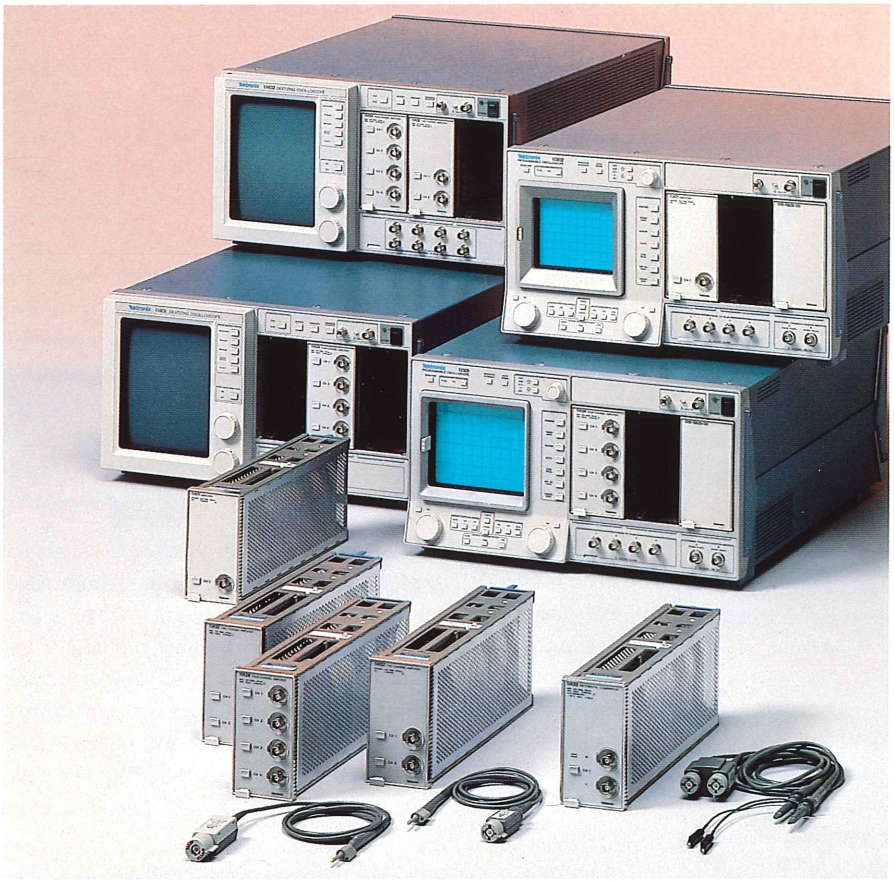

The 11000-Family from Tektronix includes four new mainframes, five new plug-ins, and three new probes.

When you first see a new 11000-Series Oscilloscope from Tektronix, you know this is something different. The simple, clean lines of the front panel, the large display screen, and the new form factor tell you that these are instruments like none you've ever seen before.

But beneath this simple, yet exciting, exterior is more measurement power than ever before designed into a stand-alone oscilloscope. The following article describes the common features and design goals of the new 11000-Family. Companion articles provide details on the new analog oscilloscopes, digital oscilloscopes, amplifier plug-ins, and probes which make up the initial offering in this exciting new oscilloscope family.

Oscilloscopes exist for one reason only — to make measurements. However, the measurement requirements of today's technologies are quickly outpacing the capabilities of conventional oscilloscope architecture.

For example, four-channel scopes are no longer adequate for many applications. Today's circuits — especially digital circuitry — often require simultaneous viewing of up to eight waveforms. There also needs to be a faster way to get more information about each waveform and its inter-relationship to others without resorting to computers and extensive software support. Detailed and complete measurement results need to appear on the oscilloscope screen — directly, in real-time, and with minimum bother.

But meeting today's multiple waveform display and processing requirements with traditional oscilloscope architecture leads to overwhelming front-panel complexity and confusion. Look at a traditional four-channel laboratory oscilloscope. Then just consider doubling its basic capability. There wouldn't be enough room for the necessary controls in the conventional format, let alone room for additional measurement capability. Even if such a scope were built, imagine the confusion in using it.

Breaking this capability/complexity barrier requires a completely new oscilloscope architecture. That architecture has been implemented in a new generation of oscilloscopes from Tektronix, the 11000-Family.

Introducing the 11000-Family

The 11000-Family includes four new mainframes, five new plug-ins, and three new probes. Both analog and digitizing oscilloscopes are included, providing bandwidths ranging from 400 MHz to 1 GHz. All of these scopes combine advanced measurement power with a new touch-screen human interface on a large-format display screen. The result is a series of advanced oscilloscopes with extremely clean front-panels (Figure 1) providing faster user access to all capabilities. At the same time, up to eight traces can be displayed simultaneously.

What's more, there's been absolutely no compromise in performance. In fact, bandwidth, accuracy, resolution, record length — all the familiar performance criteria — have been either maintained at state of the art levels or advanced to new levels. And all 11000-Series scopes — analog scopes included — offer automatic set up and measurement of common waveform parameters such as period, frequency, peak-to-peak amplitude, and minimum, maximum, and middle levels.

At the same time, prices have been kept extremely low, considering the capabilities provided on a per channel basis. For example, the 11300-Series analog scopes contain a built-in universal counter-timer that compares with some of the most sophisticated in the world. Yet these analog scopes, with the counter-timer included, cost about the same as the nearest comparable stand-alone counter-timer. Moreover, the 11300-Series counter-timer is far easier to use than stand-alone units while providing new and unique measurement features.

In addition, the cost of ownership of these new scopes has been reduced through at least a doubling of the recommended time-between-calibrations — a statement of Tek's confidence in the performance of these new instruments. When it is time to recalibrate, the process is significantly reduced through the extensive use of on-board diagnostics and calibration aids. Finally, the enhanced accuracy mode, which is standard on all 11000-Series scopes, ensures that you can make the most accurate measurements possible with any oscilloscope system.

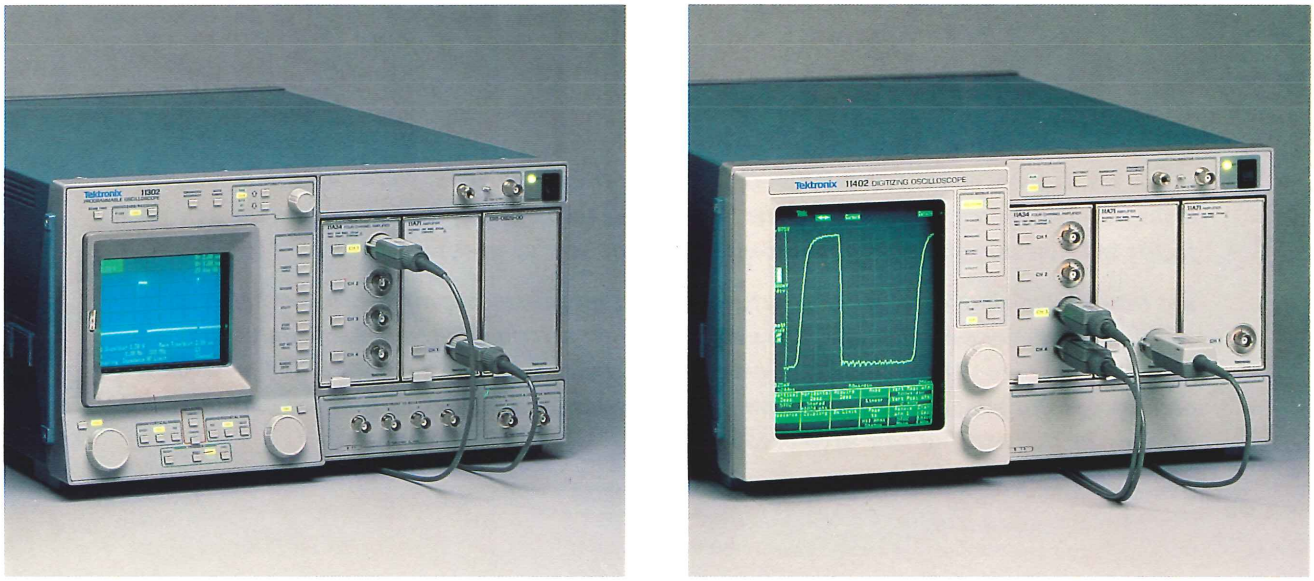

Figure 1. *Front panels of the 11000-Family are clean and uncluttered. The 500 MHz 11302 Programmable Oscilloscope is on the left and the 1 GHz 11402 is on the right.*

Human interface at the measurement plane

Providing advanced capabilities with quick and easy user access required numerous engineering innovations, including a completely new approach to oscilloscope operation and architecture. Multiple microprocessors handle the complexities of switching and interfacing while making operation simple and straight forward. A computer-bus architecture with distributed processing was literally designed into the oscilloscope mainframes and plug-ins. A bus structure is even included in the probe leads to handle SRQs (GPIB service requests) and other automatic functions that can be invoked by pressing a button available on all new 11000-Series probes.

A primary goal in overall 11000-Family design was to move user access to scope control away from the myriad of knobs and down to the measurement plane — the area where your focus is directed during a measurement. For example, the first area of attention when making a measurement is attaching probes to test points. After a 11000-Series probe is attached, pressing a button near the probe tip automatically sets up the basic scope functions to bring a usable signal display onto the screen. The same button can also be assigned to sequence through a stored series of up to 10 complete front-panel settings, to issue an SRQ to an external computer, or to invoke automatic waveform measurements.

The next and most important measurement plane is the oscilloscope display itself. This is where actual waveform observations and measurements take place. To concentrate measurement access on and around the screen, the traditional method of dealing with mainframe and plug-in switches and controls was redefined. Instead of one knob or switch per function, control was moved to a few knobs and buttons next to the display screen — and to the screen itself (Figure 2). Full control is concentrated at the screen, where measurements are taking place to allow you to keep your eyes on the trace and your attention on the measurement.

Most selections are made by touching a label, icon, or waveform on the screen. Details of the touch screen are given in the sidebar **Touch screen provides front-panel simplicity**. Control is simplified through a scheme of parallel on-screen pop-up menus (Figure 3). This menu scheme is similar to user-friendly software designed for personal computers. Except, with the 11000-Family, you don't press function keys or click a mouse. Access is more direct and much faster. Just touch the screen menu for the functions you want and touch the waveforms or labels you want the functions to apply to. It all happens at the screen where your attention is focused during measurements. And it happens in real time, with function changes and measurement results appearing as quickly as you select them.

An added benefit from this approach is that each menu presents only the selections that are currently valid for the measurement at hand. You don't need to decide which knob in which area of the panel will produce the desired affect. Nor do you need to be concerned about turning the wrong knob and upsetting your measurement setup.

As you select different menus, the two large control knobs are assigned separate functions. For one menu, these knobs may provide vertical positioning and select vertical deflection factor; for another, cursor positioning; and so on.

Automatic setup

Getting a display on the screen has never been easier. Just touch the probe tip to the signal source and press the button on the probe body. The selected signal is automatically scaled both vertically and horizontally, a trigger point is chosen on the selected waveform, and the waveform is positioned on the CRT. You can also push the front-panel AUTOSET button to get the same results.

The autoset display may not be ideal for all measurements. In such cases, just press AUTOSET (or the button on the probe) to get a preliminary setup. Then refine individual settings to provide a display that meets your measurement needs.

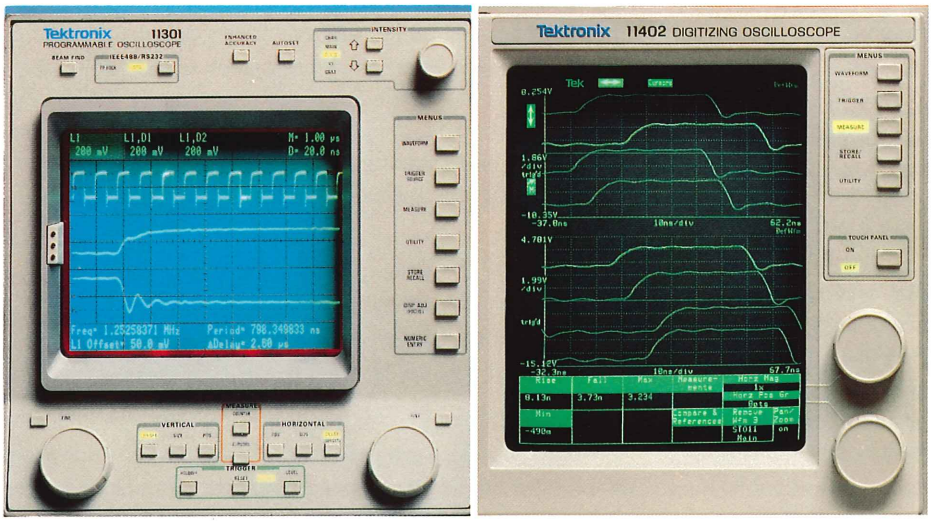

Figure 2. *Controls for the 11000-Family are grouped around the display. Notice the two large redefinable control knobs below the 11301 CRT (left) and beside the 11402 CRT (right).*

Case of the missing horizontals

The new 11000-Series mainframes accept up to three new 11000-Series plug-ins. The 11300-Series can display up to eight traces from any combination of plug-ins in the left and center

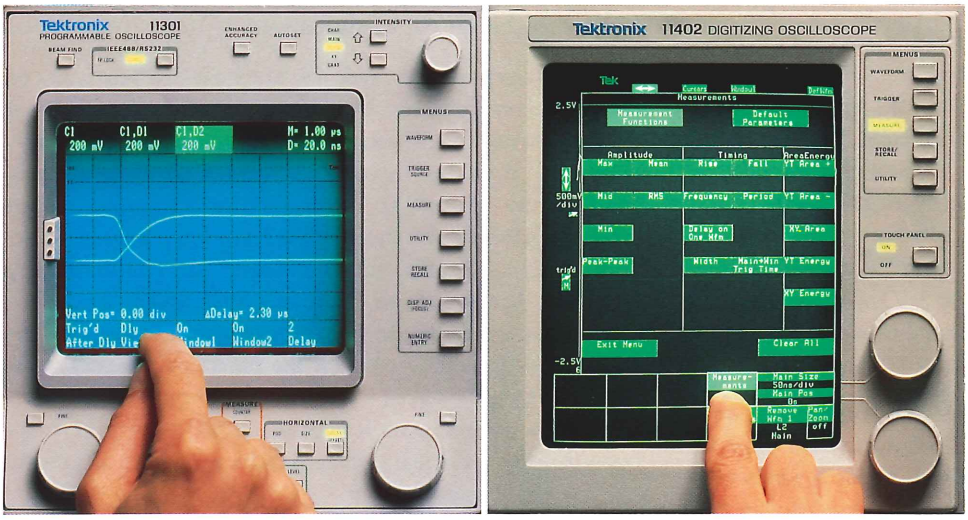

Figure 3. *Pop-up menus provide quick, easy access to measurement functions. A simple touch selects a menu item.*

compartments while the 11400-Series can display signals from the right compartment as well (up to a maximum of eight). For more detail on available plug-ins, see **Select your performance with 11000-Series plug-ins** in this issue.

One apparent omission from this new plug-in line-up is a time base plug-in. In analyzing use of earlier plug-in instruments, it was found that the horizontal plug-ins were rarely, if ever, interchanged. As a result in the 11000-Family, accurate time bases were designed into the mainframe circuitry. However, provision is made for all functions that need an amplifier in the horizontal channel such as X-Y displays and external horizontal input.

Automatic measurements

Through the "measure" menu on the touch screen, up to six pulse-parameter measurements can be selected on the 11400-Series and up to eight on the 11300-Series. Then as a signal is displayed, the selected parameter measurements for that signal are automatically performed and the results displayed on the CRT. These values are also available over the GPIB or RS-232C bus for automatic data logging, for making process control decisions, etc.

Need more accuracy?

Before the 11000-Series oscilloscopes, special calibration techniques have always been required in order to get oscilloscope measurement accuracies better than the traditional 2 or 3%. But this has all been changed. Each 11000-Series mainframe contains a precision voltage and timing reference for self-calibration. Once the instrument reaches operating temperature, a simple press of a front-panel button (or an instruction via GPIB or RS-232C) invokes a self-calibration of all gain and timing-related functions — from input connector to display screen. A special probe-calibration routine even allows automatic calibration all the way to the probe tip. And this enhanced-accuracy state applies to all measurements until the instrument is turned off, until an internal sensor detects an ambient temperature change of ±5 degrees C, or a plug-in unit is changed. A warning message is issued to the screen when the instrument can no longer make enhanced-accuracy measurements.

Provision is also made to guide you through probe compensation. One of these probe-calibration steps allows you to "deskew" probes as well as the associated channel to match delay through any two channels for precision time-delay measurements.

Designed for systems ... but at home on the bench

With all of the built-in measurement power, the 11000-Family is a system in itself. But there are times when these powerful new instruments need to be part of a larger measurement system. The 11000-Family was designed with system applications in mind to allow an easy move to computer augmentation and programmed control when needed.

All of the 11000-Series scopes come standard with both an IEEE-488 (GPIB) and an RS-232C interface. They are fully programmable over both interfaces and, in the case of the digitizing versions, full bi-directional waveform transfers are supported. This allows complete integration of these scopes into fully automated test and measurement systems, or into any level of engineering bench automation supported by a personal computer, workstation, or mainframe. GPIB and RS-232C commands are identical and comply with Tek Standard Codes and Formats to allow the ease of programming and compatibility typical of Tektronix programmable instruments.

Also, since all 11000-Series scopes come standard with an RS-232C interface — the same interface found on most personal computers — the communication hardware is already in place for many engineering bench applications.

Setting up the interface between the 11000-Family and a computer has also been simplified. A "pop-up" menu allows you to select all the interfacing parameters with a simple touch or a turn of a knob. To reduce software development time, utility software which provides pre-programmed modules covering many standard instrument functions is available for the IBM PC and the Hewlett-Packard Series 200 computers.

To make system applications easier, these instruments can be easily converted from bench to rackmount use. All that is needed for rackmounting is removal of the feet and replacement of the side panels with rackmounting hardware. Cable feed-throughs for routing signals from rear to front — an important feature in system applications — are either standard or can be added with a simple option.

Supported by Tektronix

Behind these new instruments you have all the support you've come to expect from Tektronix — and more! Each instrument is supported by complete documentation — comprehensive operator's, programming, and service manuals (optional). Measurement software is also available for a variety of computers. If your application requires a customized approach, trained Tektronix Application Engineers are available to assist — just call your local Tektronix Field Office and ask for information on our Technical Assistance Services. Or call 1-800-426-2200, ext 7446 for the name and number of the nearest Tektronix Application Engineer. In Oregon, call 1-627-9000, ext 7446 collect.

A new feature with the 11000-Family is the first on-site service for oscilloscopes. Installation, preventive maintenance, performance verification, and fast troubleshooting can now all be performed at your location, making back-up instruments virtually unnecessary. See the article **On-site service available for 11000-Series** in this issue for further information.

A base for the future

Now you've met the new 11000-Family from Tektronix. But this is only the beginning of a whole new way of making measurements. These new scopes will change your world of oscilloscope measurements forever — you'll never make measurements the old way again. And this measurement capability is built around an oscilloscope architecture designed to not only meet the measurement needs of the '80s and '90s, but to carry over into the 21st century.

But these few pages don't allow enough room for us to tell you everything about these new instruments. For more information, read the accompanying articles on the new 11000-Family in this issue. Then, check the appropriate boxes on the **HANDSHAKE** reply card for a detailed brochure on the products that will best fill your measurement needs. Or call your local Tektronix Field Office or sales representative for a demonstration. And be sure to tell them you saw it in **HANDSHAKE.**

Touch screen provides front-panel simplicity

The designers of the new 11000-Series oscilloscopes were faced with a real dilemma — how to expand the functionality of these new oscilloscopes far beyond anything previously available while maintaining a simple, friendly approach to operation. The solution was found in a touch-screen CRT.

The touch screen is made up of a bank of infrared LEDs along two sides of the CRT with corresponding infrared sensors along the other two sides (see Figure A). This overlays the CRT screen with an invisible grid spaced so you cannot touch the screen without breaking at least one of the beams. The LED/sensor pairs are scanned one pair at a time every six milliseconds. Any interruption of the LED-to-sensor beam is detected, mapped as to location, and processed to activate the desired function based on the menu that is displayed.

Menus are generally called up by the buttons located adjacent to the CRT. Some menu selections call up an additional sub-menu. In no case, however, is it necessary to "back out" of a menu. You can always move directly from any level in any menu to the top level of any other menu with a single press of a button or a single touch on the screen. No menu is more than three levels deep.

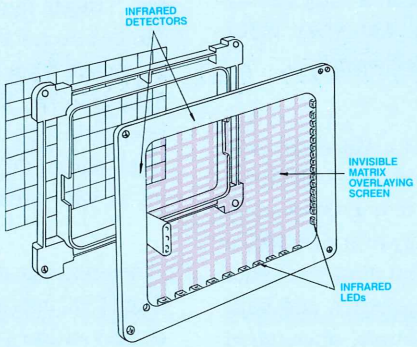

Figure A. *Detail of touch-screen matrix overlaying the CRT.*

To prevent the touch screen from showing fingerprints or smudges which might obscure the display, a special non-glare surface was put on the CRT. The result is an easy-to-read display even after extended periods of use.

It only takes a few minutes of introduction to feel right at home with touch-screen operation. A touch in the main menu area selects a pop-up menu which presents only the selections applicable to current operations. Further selection of the main menu choices is provided by the menu selection buttons to the right of the display. Before you know it, you'll be making measurements with these scopes. In fact, you'll probably find the touch-screen interface so convenient and easy to use that you'll have trouble going back to conventional knobs and switches.

11300-Series extends the usefulness of analog scopes

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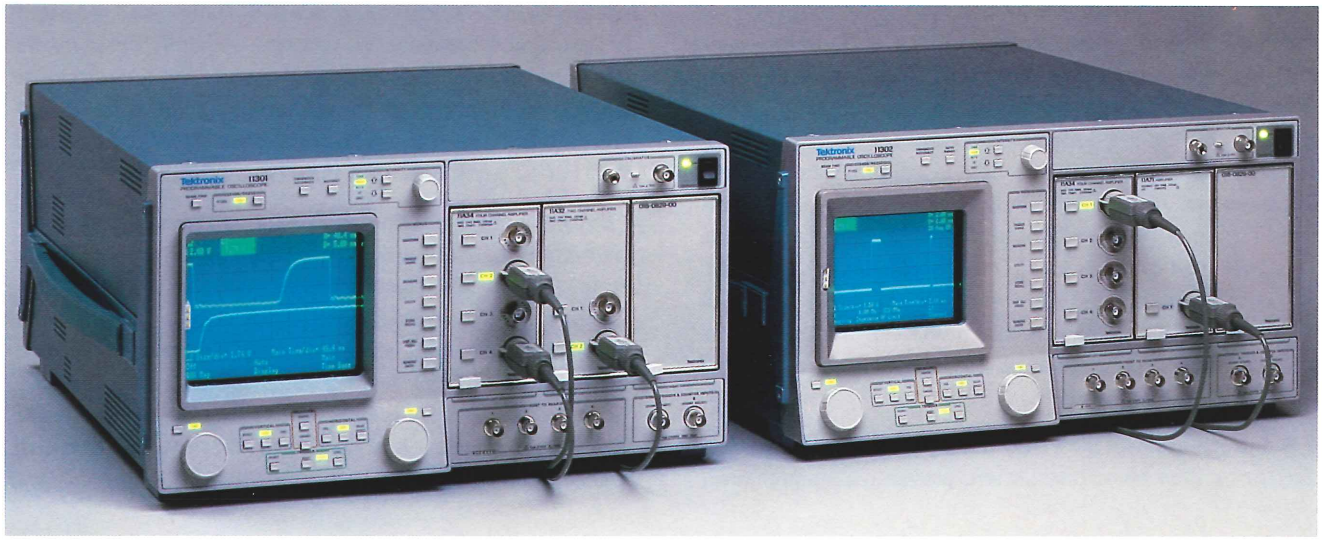

The new 11300-Series analog oscilloscopes from Tektronix. 400 MHz 11301 Oscilloscope on left, 500 MHz 11302 Oscilloscope with microchannel-plate CRT on right

Analog scopes have provided the foundation for precision measurements for the past four decades. But recent advances in digital measurement techniques have eroded this base. In fact, some manufacturers of digitizing oscilloscopes would like you to believe that analog scopes have outlived their usefulness (see sidebar **Analog scopes are alive and well**).

In designing a new family of oscilloscopes, Tektronix engineers had to rethink the position of the analog scope in the measurement world. The result was a new commitment to the analog oscilloscope because it provides measurement capability unattainable by any other means. As a result, Tektronix is proud to introduce the latest in a long history of precision analog oscilloscopes — the 400 MHz 11301 Oscilloscope and the 500 MHz 11302 Oscilloscope.

New from the outside

The 11300-Series analog oscilloscopes have a whole new look from the outside, a look which they share with the 11400-Series digitizing oscilloscopes — all part of the new 11000-Family from Tektronix (see preceding 11000-Family overview article **Tektronix redefines the oscilloscope**). The first thing you notice is an all new size and shape — low on the bench and built for rackmounting. Then you notice the simple, uncluttered front panel made possible by the touch-screen interface (see **Touch screen provides front-panel simplicity** in 11000-Family overview).

New from the inside

There's more to the 11300-Series Oscilloscopes than meets the eye. Inside are many of the familiar circuit modules you would expect to find in any analog oscilloscope (see Figure 1). But these familiar circuits are augmented by some circuitry you wouldn't expect to find in an analog scope — such as a microprocessor-based Main Processor system and a built-in 500-MHz universal counter-timer.

Briefly, the 11300-Series circuits operate as follows: Signals for vertical deflection are applied to the Left and Center Plug-Ins. Trigger signals for both the Main and Delayed Trigger can be selected from these plug-ins as well as the Right Plug-In. Signals from the Center Plug-In can also provide horizontal deflection for X-Y displays. The Main and Delayed Sweeps operate in a conventional manner except that they are an integral part of the mainframe circuitry rather than being in plug-ins as with previous Tektronix plug-in oscilloscopes.

Selected signals from the plug-ins are displayed on the CRT. The 11302 uses a microchannel-plate CRT to provide a bright display of low-repetition rate or single-shot transient signals up to the 500 MHz bandwidth even in normal room light (see sidebar **Microchannel-plate CRT and Digital Camera System capture fast signals** for more detail).

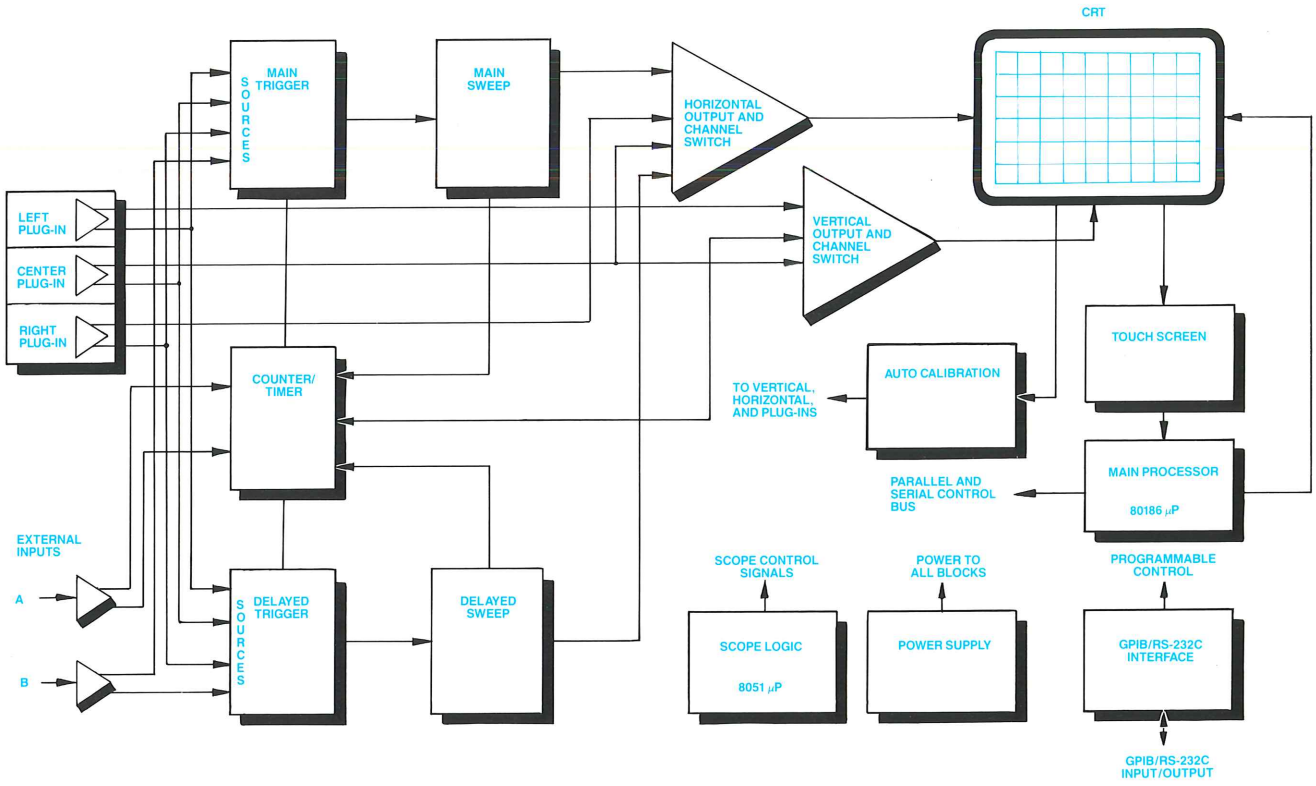

Figure 1. *Simplified 11300-Series block diagram*

Virtually all operation of the 11300-Series, including the plug-ins, is controlled through the Touch Screen. This circuitry senses a touch on the CRT screen which is interpreted and acted upon by the Main Processor. The pushbuttons adjacent to the CRT call up the various menus for the touch screen. The two large control knobs below the CRT perform various functions as assigned by the pushbuttons or the menu selections. Characters and graphics for menu selection, operator prompts, status information, measurement results, and cursors are produced by the Main Processor.

The Scope Logic stage generates signals to control the analog circuits (e.g., switching logic, signal selection, sweep control, etc.). Programmable control for all functions of the oscilloscope is provided via both IEEE-488 (GPIB) and RS-232C by the GPIB/RS-232C Interface.

The Enhanced Accuracy mode provides automatic self-calibration of the gain and timing of the vertical and horizontal systems including all installed plug-ins. The Auto Calibration circuit provides accurate voltage and timing references. Optical sensors on the CRT bezel sense when the beam crosses the graticule lines to factor this information into the auto cal control signals. As a result, accuracy of the 11300-Series is controlled from the plug-in input connector to the CRT graticule without operator intervention. Provision is also made for calibration to the probe tip when an 11000-Series probe is used.

At the heart of these unique analog oscilloscopes is the 500-MHz universal counter-timer. This counter-timer provides measurement of frequency, period, width, ratio, totalize, and time A→B. Measurements can be made on any of 12 different plug-in input channels and/or from the external A and B inputs. A counter-view function allows display of signals from within the counter to show exactly what is being counted. This is especially useful on gated measurements or in measurements on complex signals where positioning of a gate or triggering level can easily produce a false reading with a conventional counter.

Power for all circuits in the 11300-Series mainframes, associated plug-ins, and active probes is provided by the Power Supply.

Is it a scope with a built-in counter-timer or a counter-timer with a built-in scope?

It's hard to tell whether the 11300-Series should be described as a precision oscilloscope with a built-in counter-timer or an extremely versatile counter-timer with a built-in scope. Either way, it adds up to precise measurement capability unequaled in any other single package. By combining a high-performance universal counter-timer with a high-performance oscilloscope, Tektronix simplifies the most difficult counter-timer measurements while adding capabilities never previously possible with a counter-timer alone. And all this combined measurement power is available for the price you would pay for either a precision oscilloscope or a high-performance counter-timer alone.

Combining an oscilloscope and a counter-timer provides other benefits besides lower equipment cost. For one, you only need to allot space on your bench for one instrument rather than two. And then, both functions are always available and can be accessed with a single connection to the circuit-under-test. By taking advantage of oscilloscope resources — such as delayed sweeps, multiple trigger inputs, high-sensitivity inputs, interchangeable plug-ins for signal conditioning to match signal demands, and a CRT display of what you're counting — counter measurements are moved to new dimensions.

See what you're counting with counter view

Measuring pulses without the new counter-view feature which is standard on the Tektronix 11300-Series is like counting paper currency in the dark — you know how many bills you have but you aren't sure what your fortune is worth.

A unique feature on the 11300-Series is a Counter View mode — essentially what the counter is actually "seeing" and how it is being interpreted. This counter-view signal can be compared with the analog oscilloscope signal to show exactly what is being counted. Now you can adjust and control counter measurements with greater precision and complete confidence.

Several signals are available for counter-view display. In all cases, the counter-view display is shown as a binary signal (only two levels) representing the triggering points.

- **Count In** displays the actual counted events as detected by the counter-timer.
- **Gate** shows the gating signal that is used to exclude or mask unwanted portions of the signal from the measurement.
- **Sync Gate** displays the actual interval during which the counter performs the measurement.
- **A Ext and B Ext** shows the detected signal present at the A External or B External inputs.

The Counter View feature is helpful when making any type of counter measurements, but it becomes almost indispensable for making accurate measurements on complex waveforms. For example, trying to measure the frequency of only the signal burst on the waveform shown in Figure 2 with a conventional counter often results in too low a reading because the counter averages the pulses over a fixed time interval (see waveform and frequency results on left).

However, you can easily get the correct frequency reading by confining the measurement to only the burst signal. This is easy to set up with the 11300-Series counter-view feature using the delayed sweep to provide a gating signal. Then while observing the time relationship between the signal and the counter view gate, you can adjust the duration and position of the gate so only the burst signal of interest is counted (see waveform and frequency results on right). Since the measurement interval has been confined to the burst signal you want to measure, the frequency measurement is now correct.

Accurate one-touch measurements

With the 11300-Series, complex measurements are reduced to a simple touch. Pressing the AUTOSET button on the front panel (or a button on the probe tip) captures and displays an automatically scaled, correctly triggered signal.

Press the MEASURE button and then select up to eight common waveform parameters from the menu for automatic measurement on the selected waveform. Results are displayed on the screen or made available over the GPIB or RS-232C bus.

Delayed sweep measurements, counter-timer measurements, cursor measurements — these are just some of the measurements that can be made easily from the touch screen. To end confusion over which knob to turn or which button to press when making a measurement, the touch-screen interface narrows your choice of functions to those menu items appropriate to the task.

You can even select enhanced-accuracy measurements with a single touch. Pressing the ENHANCED ACCURACY button after the instrument has reached a stable operating temperature (20 minutes after power turned on) invokes an auto cal routine to provide the most accurate measurements you can make with any analog oscilloscope. Special probe calibration functions are also provided for compensation and deskewing (matching time delay through the probes and associated channels). And to ensure that you're always making measurements to the expected accuracy, a warning message tells you when enhanced accuracy no longer applies — instrument has been turned off, plug-ins have been changed, or the temperature changed ±5 degrees C.

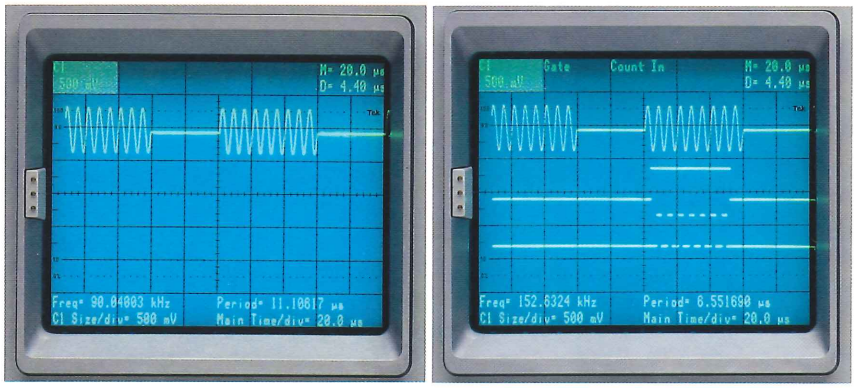

Figure 2. *Typical counter produces the incorrect frequency (90.04003 KHz) reading shown on the left. With Counter View as shown on the right, you can get the correct reading (152.6324 KHz) by positioning the gating signal so only the burst signal of interest is counted*

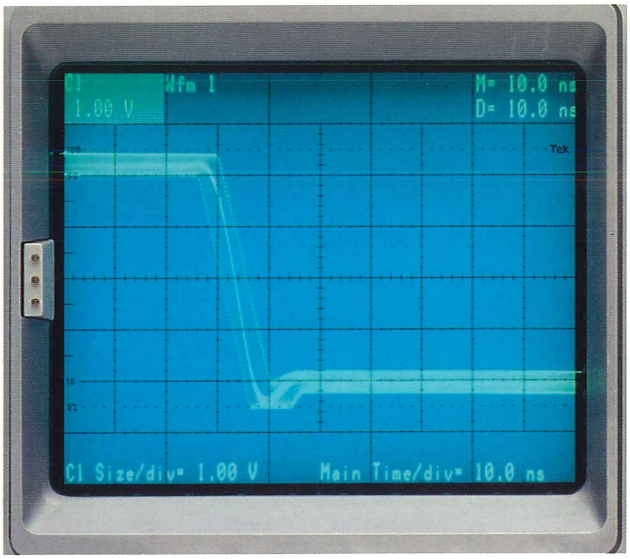

Figure 3. *Displayed waveforms can be compared to stored reference waveforms for quicker visual go/no-go comparisons. In this case, the "live" waveform is compared to a stored "tolerance band."*

Easier measurements with cursors

Vertical or horizontal cursors can be displayed to aid in making amplitude and timing measurements. When using cursors, signal variations can be measured in percent, dB, or degrees without the need for additional calculation. The numeric result of cursor measurements is always displayed on the screen along with the appropriate units of measure.

Reference waveforms for comparison

Although these analog scopes cannot digitize and store input waveforms, a special memory allows two reference waveforms to be stored and displayed for comparison purposes. These reference waveforms can serve as templates for quick visual go/no-go comparison (see Figure 3). The reference waveforms can be downloaded to the template memory over the GPIB or RS-232C bus.

For more information

There just isn't enough room in this article to tell everything about the new 11300-Series analog oscilloscopes. If you would like to know more about what the 11300-Series can do for your measurements, contact your local Tektronix Sales Engineer or representative for a videotape preview or a hands-on demonstration. For a brochure, check the appropriate box on the **HANDSHAKE** reply card.

With appreciation to Paul Thompson, Tektronix Laboratory Instruments Division Marketing, for technical assistance in preparing this article.

Analog scopes are alive and well

Mark Twain is reported to have cabled the Associated Press from London in 1897 with the message "The reports of my death are greatly exaggerated." This same message could be applied to analog scopes today as many are saying they're dead and gone — some companies have even decided to get out of the analog scope business.

But Tektronix is committed to the analog scope — not out of tradition but because there are certain measurements that can only be made using analog techniques. Digitizing techniques have just not advanced to the point where digitizing oscilloscopes can take over all oscilloscope applications.

As long as a signal is repetitive and always behaves as expected, a digitizing oscilloscope will generally perform as well or better than a comparable analog oscilloscope. And besides, they give you some added benefits like digital storage, almost unlimited waveform manipulation capability, save on delta, hardcopy output, comparison with a reference, digitized waveform output for computer analysis, etc., etc.

That's all well and good as long as the signal is fairly stable. However, if the signal is constantly varying, the display from a digitizing oscilloscope can be almost incomprehensible. In some digitizing oscilloscopes, this is offset by using a point-accumulate mode which shows the outer limits of the signal variations. But it still doesn't show you what the individual variations were within these limits. In order to see and measure these variations, you need a fast, bright analog oscilloscope such as the 11301 or the 11302.

Another limitation of digitizing oscilloscopes is that the signal must be repetitive. From both a practical and economical standpoint, digitizing scopes cannot capture single-shot signals with frequency components in excess of a few megahertz. Some specialty digitizers can perform up into the gigahertz range, but their price eliminates them from consideration in all but the most important and demanding applications.

For the foreseeable future, there will remain a need for real-time analog oscilloscopes. At the same time, there are applications where a digitizing oscilloscope may provide the best answer. That's why Tektronix doesn't lock you in to either analog-only or digital-only measurements but gives you a choice — the 11300-Series analog oscilloscopes and the 11400-Series digitizing oscilloscopes. And they're both part of the new 11000-Family from Tektronix, sharing common architecture, operating features, and plug-ins.

Microchannel-plate CRT and Digital Camera System

What is a microchannel plate?

Microchannel-plate technology provides one of the major technological breakthroughs in the effort to increase CRT writing rate for the display of single-shot phenomena. A microchannel-plate CRT is quite similar to a conventional CRT. The major difference is the microchannel plate (MCP) located just behind the CRT phosphor screen. Figure A shows the details of an MCP CRT.

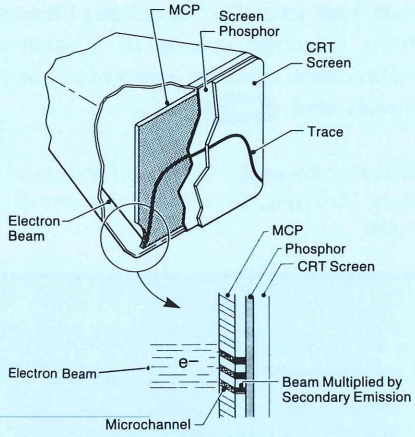

Figure A. *Detail of microchannel-plate CRT showing how an electron beam is amplified*

The MCP is a 0.050-inch thick glass plate with millions of tiny (approximately 25 micron), closely spaced holes (microchannels). These holes are offset angularly from the beam axis by about 15 degrees and are internally treated to promote the generation of secondary-emission electrons.

When the electron beam scans across the MCP, electrons enter the holes and strike the treated sides. This causes secondary emission within the channel which is amplified by further secondary emission as it moves down the channel. The amplified electron beam exits the channel and travels the short distance to produce a trace on the phosphor screen.

Because of the channel multiplication of beam electrons, trace brightness is increased, even for extremely fast traces that would otherwise not be visible on the CRT. Individual channels of the MCP saturate in regions of high trace intensity while maintaining full gain for less intense portions. This feature called "adaptive intensity" tends to normalize overall trace intensity between high and low repetition rate signals. Bright traces are limited to a safe viewing level while the intensity of dim traces is increased for good visibility.

Digitizing Camera System makes 11302 a 500 MHz, 100 gigasample/second transient digitizer

The Tektronix Digitizing Camera System can turn the 11302 Oscilloscope into a 500 MHz transient digitizing oscilloscope with an effective single-shot digitizing rate in excess of 100 gigasamples per second. The Digitizing Camera System consists of the C1001 Video Camera which mounts on the CRT bezel, a Frame Store Board which mounts in an IBM PC or compatible, and DCS01 Software for waveform processing. An optional video copier provides high-resolution black and white prints of waveforms at low cost.

Used with the 11301 Oscilloscope, the Digitizing Camera System can acquire repetitive events at full bandwidth and transient events to the limits determined by the photographic writing rate of the CRT. On both the 11301 and 11302, the Digitizing Camera System allows waveforms to be digitized, stored, and displayed. Routines in DCS01 Software can perform many waveform processing operations on the acquired waveforms.

To find out more about the Digitizing Camera System, contact your local Tektronix Field Office or sales representative. For a brochure, check the appropriate box on the **HANDSHAKE** reply card in this issue.

Figure B. *Digitizing Camera System turns the 11302 Oscilloscope into a 500 MHz transient digitizer*

New digitizing oscilloscopes simplify high-resolution multi-channel measurements

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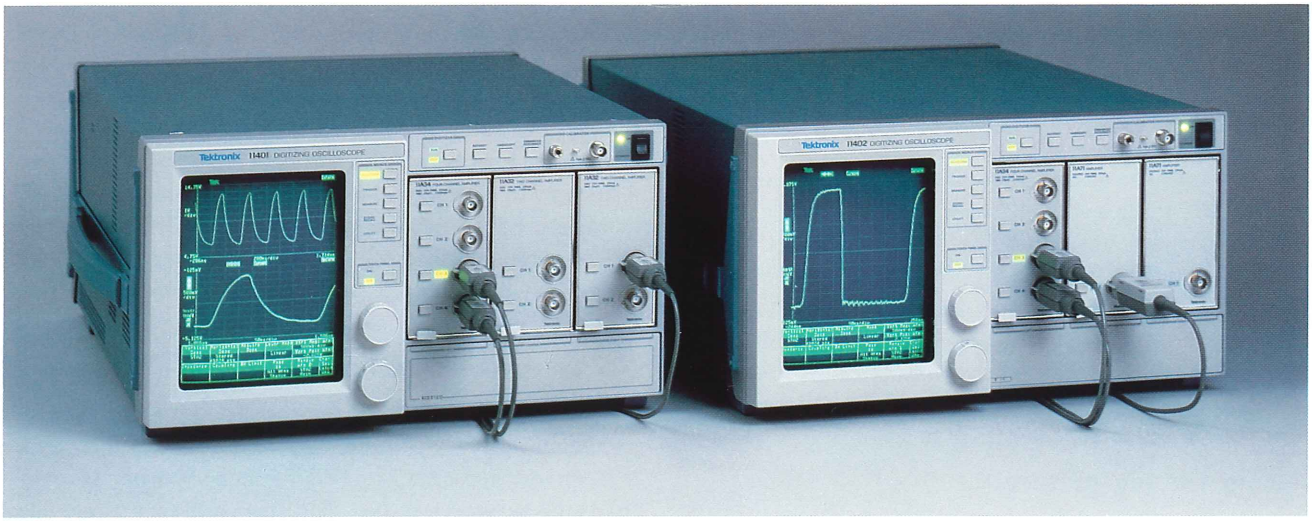

The new 11400-Series from Tektronix. 500 MHz 11401 Digitizing Oscilloscope shown on left, 1 GHz 11402 Digitizing Oscilloscope shown on right.

Designers of the new Tektronix 11400-Series digitizing oscilloscopes had one primary goal in mind — to create a closer link between an engineer or technician and a measurement solution. In addition, they set out to advance the measurement capabilities of digitizing oscilloscopes beyond anything currently available. In the process, nearly every aspect of the oscilloscope from the probe to the CRT has been improved. The result is the 500 MHz 11401 Digitizing Oscilloscope and the 1 GHz 11402 Digitizing Oscilloscope.

In this article, we would like to show how these design goals were met. But more important, we would like to show you what this means on the bottom line — making measurements in the real world.

The 11400-Series Digitizing Oscilloscopes share many features with other instruments in the new Tektronix 11000-Family. These common features are described in the preceding 11000-Family overview article **Tektronix redefines the oscilloscope**.

Measurements are a touch away

The 11400-Series uses a new touch-screen interface to reduce front-panel clutter and provide fast, easy measurements. Details of the touch screen are described in the preceding 11000-Family overview article. To the touch-screen features standard on all 11000-Family instruments, the 11400-Series adds some refinements to meet the unique requirements of digitizing oscilloscope measurements.

A very helpful icon on the 11400 display is a "trig'd" arrow (Figure 1). This arrow indicates that the display is trig-

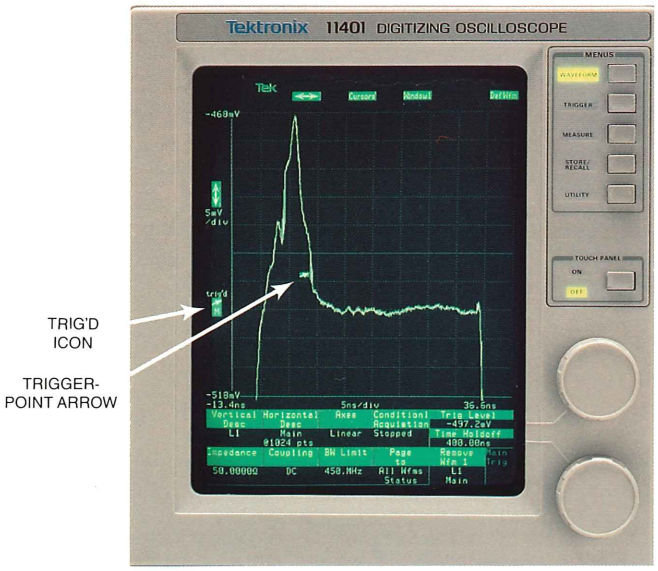

Figure 1. *Icon on display indicates triggered display. Additional arrow shows exact point on waveform where triggering occurs.*

gered and whether it is triggered on the main or windowed waveform. When the trigger is DC coupled, an additional arrow shows the exact point on the displayed waveform where triggering occurs — particularly useful when multiple waveforms are displayed or when pretriggering is used.

An individual waveform can be selected from the displayed set of waveforms simply by touching it. The selected waveform immediately becomes brighter than the other waveforms and all menu functions now apply to this waveform. This is a real time saver versus guessing which controls apply to which waveform, or tracing a signal back to the input channel and then back to the source before adjustments or changes can be made.

Further measurement ease is provided through a feature that can be called "touch and drag." As soon as you touch a point on the screen, a bright box is drawn around that point to acknowledge the touch. If the box doesn't include the function you intended to select, simply drag your finger across the screen until the appropriate function is boxed. Then, lift your finger and the selected function activates. This provides not only visual feedback of your selection but also allows you to refine your selection for the desired area.

Getting the big picture

The 11400-Series display is nearly twice the size of a typical oscilloscope — nine inches diagonal. This allows enough room to display up to eight traces plus the menu/status bar at the bottom of the screen (Figure 2).

Display resolution is also significantly higher, enabling a clearer display of more information at once. This is accomplished through use of a vertical raster scan in place of the traditional horizontal scan. Vertical scanning also allows

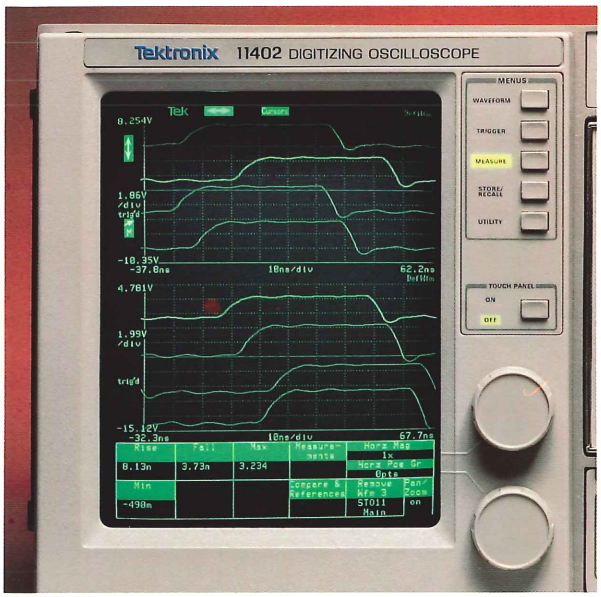

Figure 2. *Large display of the 11400-Series allows display of up to eight traces plus the menu/status bar.*

faster update of the screen, giving a display that approaches "real time" in appearance. Side benefit of the vertical scan technique is a simplified display controller and the ability to locate the main menu selection boxes along the bottom of the screen rather than on the sides.

In addition, the update rate on the display is so fast that you'll swear it's real time. This is particularly useful when making measurements that require immediate feedback — for example, adjusting overshoot on a pulse. With many digitizing oscilloscopes, there's a delay while the display is updated creating a "rubber band" effect. In order to prevent overcompensation, you have to wait to see the results of your "tweak" before proceeding — a time consuming and confusing process. But not so with the 11400-Series. Since the display is updated in near real-time, you get immediate feedback of the results. You can also get immediate feedback of parameters on the measurement menu. As a result, you can use these digital values for accurate setup and adjustment the same as you would the readout from any precision digital instrument.

No sacrifice in accuracy

Some digitizing oscilloscopes compromise either vertical resolution/accuracy or horizontal resolution/accuracy as a trade-off for the benefits of digital measurements. But not the 11400-Series. These new digitizing oscilloscopes provide both accurate timing and accurate amplitude measurements in the same instrument.

In designing the 11400-Series, Tektronix engineers were uncompromising in the performance of the vertical acquisition system and the dual time bases. The vertical system has 10-bit resolution (1024 levels) which can be increased to 14 bits (16,384 levels) with signal averaging. Combining this high vertical resolution with amplifiers featuring up to ±1000 divisions of offset, fast overdrive recovery, and low noise results in a system capable of making accurate measurements on small signal details. Resolution of the dual crystal-controlled time bases can be varied to as small as 10 picoseconds/point for exacting timing measurements.

Coupled with this high resolution is selectable record length between 512 and 10,240 points. On-board waveform memory is 45,056 points standard which can be increased to 102,400 points with an option. While this sounds like a lot of on-board memory — more than any other digitizing oscilloscope — careful memory budgeting must be practiced so as not to store waveforms at a higher record length than necessary, thus conserving memory for more important events.

The pan and zoom feature is helpful for examining the details of long records. The 11400-Series display resolution is always 512 points. When longer record length is used — for example, 4096 points — the display shows the total record length but compresses the data by computing the display from the min/max data points. This shows the vertical range for groups of waveform record points (e.g., eight points for a

4096-point record) but doesn't show all waveform details. When pan/zoom is selected, you can scroll through the entire record, point by point, with the pan control and magnify an area to examine detail with the zoom control.

Rated accuracy of the two subsystems is 1% or better vertically with 100 picoseconds plus 0.002% of the measurement interval horizontally. An enhanced accuracy mode guarantees that the scope is precisely calibrated by referencing the vertical to a stable DC source and the horizontal to a high-stability crystal-controlled oscillator (see 11000-Family overview article for more detail). This assures accurate and repeatable measurements.

Touch and go measurements

The new 11400-Series user interface enables waveform acquisition, display, processing, and documentation with six touches or less. Here's how easy it is to make measurements using this "touch and go" system:

1. Touch **AUTOSET** (or a button on the probe tip) to automatically adjust vertical, horizontal, and trigger settings to display the signal(s) currently coupled to the inputs. This single touch gives a stable display of nearly any repetitive waveform.

2. Touch **MEASURE** to provide access to the measurement subsystem.

3. Touch **Measurements** on the Main Menu. This "pops up" the Measurement Menu listing all of the available amplitude, timing, and area/energy measurement functions.

4. Touch up to six areas (from a selection of 17) on the Measurement Menu to select measurements to be executed. Results are displayed in the menu/status area at the bottom of the display and continually updated while measurements are being made.

5. Touch **Exit Menu** to fold down the Measurement Menu and restore the waveform display. The waveform is displayed in the screen area and the selected measurement results are displayed in the Main Menu.

6. Touch **HARDCOPY** to send a high-resolution copy of the current display, complete with time/date stamp and measurement data from the menu/status area, through a standard Centronics parallel printer port to a dot matrix printer.

With these six simple steps you can acquire, display, process, and document almost any signal.

Open a window for a clearer view

The 11400-Series instruments allow you to get a closer look at a portion of the waveform by acquiring that portion at higher resolution. Touching the **Window 1** icon splits the screen into two separate display areas (Figure 3A). Now, the lower display represents the intensified portion of the main waveform shown in the upper display. Size and position of this intensified portion can be controlled independently with the control knobs.

For even greater detail, a second window can be opened by touching the **Window 2** icon. This produces a second intensified zone on the main waveform along with a corresponding waveform on the lower display (Figure 3B).

Windowing waveforms focuses a great deal of resolution on a specific portion of the waveform without the need to acquire the entire waveform at the higher resolution — thus conserving waveform memory and increasing measurement accuracy. However, the windowed portion of the waveform is actually reacquired at the higher resolution rather than being just a display expansion of the existing data. Used in this manner, the main waveform provides an overall wide-angle view while the window focuses in for a close-up view. In addition, using windows allows use of large amounts of pretriggering. The windows can be positioned anywhere within the main waveform whether the main waveform has 100% pretrigger, 100% postrigger, or any amount in between.

Or make your own display

The 11400-Series can display and continuously update as many as eight traces on the screen at one time. These eight traces can come from a variety of sources: Selected from the 12 possible input channels (total available depends upon plug-ins installed), from previously stored waveforms, or from a

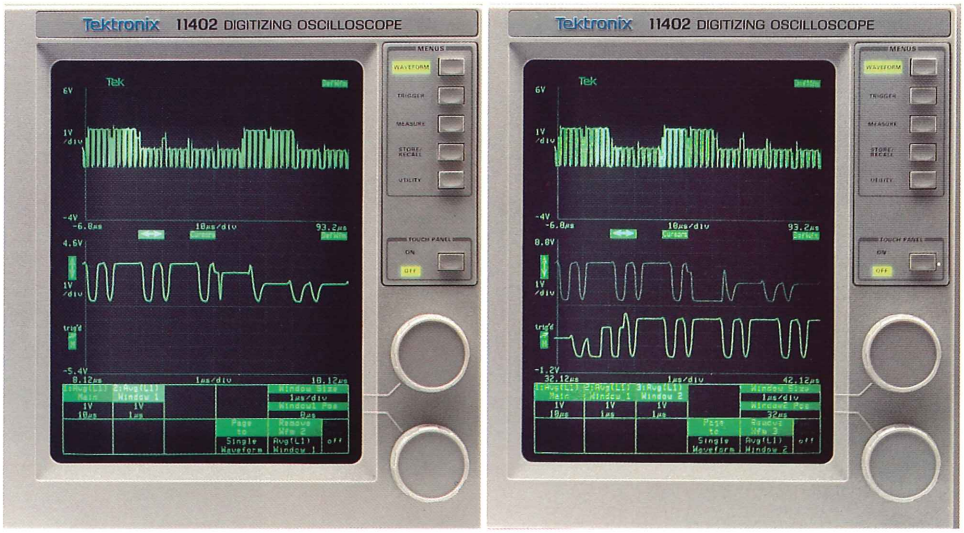

Figure 3. *(A) A window can be opened on the display to examine a portion of a waveform in detail. (B) Second window opened.*

computed waveform. This provides overall flexibility in selecting signals for display.

Most of these sources are straight forward and what you'd expect from any digitizing oscilloscope. But the ability to display computed waveforms adds unprecedented measurement flexibility. Computed waveforms can be as simple as an X-Y display — left channel 1 vs right channel 2. Or they can be more complex mathematical combinations such as an energy calculation created by taking the integral of the product of a voltage and current waveform — Int(left channel 1 x center channel 3). Another computed waveform could be a "live" waveform from a plug-in subtracted from a stored reference waveform from memory to examine the difference — stored 1 – left channel 2.

The real power of computed waveforms is that calculations are made internally to the instrument, without the aid of an external computer, and the results are immediately available for display on the screen. Depending on complexity of the calculations required, the computed results appear almost indistinguishable from "live" waveforms. What's more, all of the measurement parameters available on the Measurement Menu can be applied to these computed waveforms. Not only do you see the results of the computation almost instantaneously, but the selected parameters are continuously updated in the menu/status area as well.

Advanced measurement capability

The 11400-Series includes an extremely accurate and powerful time-measurement feature — main-to-window trigger measurements to provide high resolution and high throughput for automated timing measurement applications. Delta time between the main time base trigger event and the window time base trigger event can be measured with 200 picosecond resolution for single-shot events or 10 picosecond resolution for repetitive events using averaging. This lets you make exacting timing measurements without digitizing the waveforms and results in very high throughput. A 5 GHz clock would be required to duplicate this feature with a conventional counter-timer — beyond the current state of the counter-timer art. In addition, the 11400 can make these measurements on a single-shot, real-time basis.

Another advanced measurement capability provided by the 11400-Series is the "cross" function. This function finds the location in time of a specified voltage-level crossing. You specify the voltage or reference level, the direction (slope) of the crossing, and the limits between which the measurement is to be made. The displayed result is the time elapsed from the start of the waveform to the first crossing of the reference level with the correct slope polarity within the specified limits. This feature allows automatic measurement of propagation delay, time skew, setup and hold time, etc.

At last ... easy documentation

Documentation of measurement results is often a complicated, time consuming, and expensive process. The 11400-Series solves this documentation problem by providing a built-in Centronics printer interface. Pressing the front-panel HARDCOPY button sends a large, high-resolution copy of the current screen to a dot matrix printer (see Figure 4). Included on the copy is a time and date stamp as well as measurement data from the menu/status area.

Add it to a system

The power of the 11400-Series can enhance your system measurements. Since they come standard with both an IEEE-488 (GPIB) and RS-232C interface, these instruments can be plugged into many existing systems to provide programmable measurements or auto-calibration functions (Figure 5).

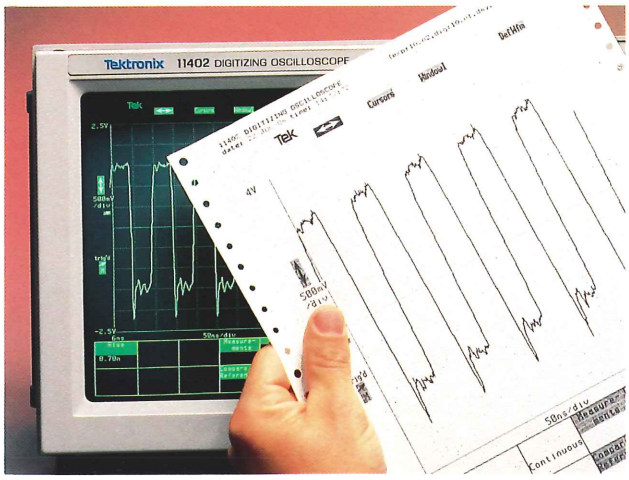

Figure 4. *Pressing the HARDCOPY button produces a large, high-resolution copy of the display on a dot matrix printer.*

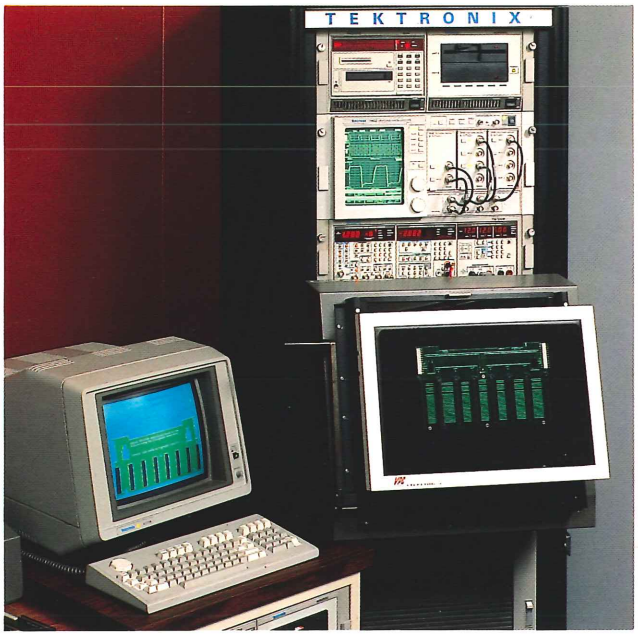

Figure 5. *11402 Digitizing Oscilloscope used with a Tektronix TSI 8150 Test System Interface in an automated system.*

There's a computer inside!

Inside the 11400-Series digitizing oscilloscope is the power of today's most sophisticated personal computers — matter of fact, the power of three personal computers. Three 16-bit microprocessors within the 11400-Series mainframe manage each of the three major modules — Digitizer, Executive, and Display (Figure A). In addition, each of the smart 11000-Series plug-ins has its own microprocessor and bus for plug-in operations.

Each of these microprocessors has its own local memory for storing data exclusive to that microprocessor's local operation. A main memory unit (MMU) associated with the Executive provides data and command exchange. All memories are loosely coupled with a common 16-bit, high-speed bus structure. All microprocessors and memory also operate under a direct memory access (DMA) scheme for high-speed data access by any part of the system.

The firmware architecture is also arranged in a similar format. A central Command Executive is surrounded by a common access path into which specialized firmware modules are plugged (e.g., digitizer control, display control, table-driven menus, etc.). The structure and operation closely follow system data base concepts and are purposely kept modular. This modularity provides both efficiency and an open-ended architecture that can easily accept future ROM extensions.

The Executive Processor (EXP) is the heart of the system. It coordinates instrument operations and processes waveforms (e.g., waveform measurements, averaging, etc.). The EXP receives Touch Panel, pushbutton, or external interface commands and directs the appropriate subsystems to perform the requested operations. Under EXP control, the Main Memory Unit (MMU) stores and transfers waveform records and provides communication channels to the Display and Digitizer. The EXP controls the Digitizer and Display by placing instruction messages in Waveform Memory and instructing the MMU to transfer the message to the appropriate subsystem. Likewise, the MMU and Waveform Memory are used to pass status information from these subsystems to the EXP.

Three separate serial communications channels give the EXP full control over the installed plug-in units. These serial links are used to send setup instructions to or read status information from the plug-ins.

The EXP controls Touch Panel operation by generating the items for display and reacting to touches. All icons, menu items, and waveform related features (graticules, axis scale indicators, etc.) are sent to the Display through a MMU DMA channel. When the Touch Panel detects a touch, it interrupts the EXP and gives it the location of the touch. The EXP then correlates this location with its current "map" of items that are selectable. When a function is selected, the EXP directs the appropriate subsystem to perform the operation and sends function status information to the Display.

In addition to the above, the EXP provides the following: Start-up diagnostics, start-up self calibration, enhanced accuracy calibration, time/date clock, GPIB and RS-232C interfacing control, waveform storage, and front-panel settings storage.

The Digitizer converts analog signals from the plug-ins into precisely timed sequences of 10-bit digital values using a high-speed analog-to-digital two-stage flash converter. Up to eight signals can be acquired at a time. The Digitizer also contains two trigger circuits, main and window time bases, and a 16K acquisition memory.

The Display generates a vectored waveform display from a waveform record and positions it on the screen. It also displays touch-panel function selections, user prompts, status information, and measurement indicators (such as cursors, peak points, etc.) from its bit-mapped display memory.

The Interface provides connection to the outside world via IEEE-488 (GPIB), RS-232C, and Centronics interfaces. In addition, this block senses actuation of front-panel buttons and passes this information on to the EXP.

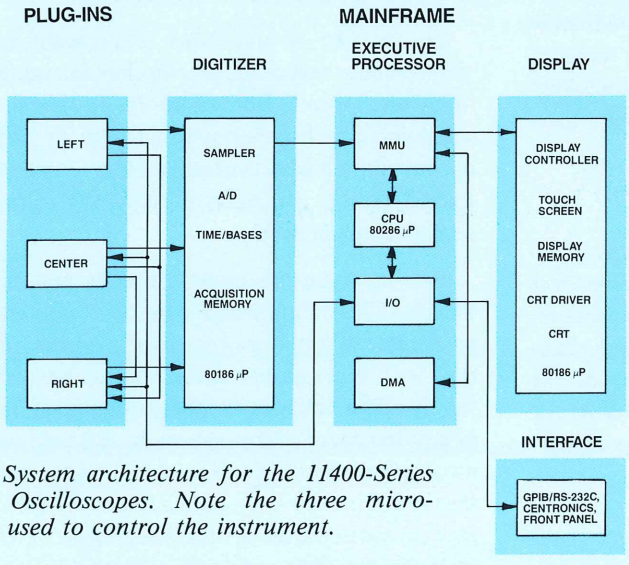

Figure A. *System architecture for the 11400-Series Digitizing Oscilloscopes. Note the three microprocessors used to control the instrument.*

An available DMA Option speeds GPIB transfers to as high as 50 1000-point waveforms/second (actual speed depends upon the type of computer and GPIB interface used).

The RS-232C interface, in particular, opens many new system possibilities. For example, many automated device testers, VLSI verification systems, and hybrid laser trimming systems operate from host computers that provide RS-232C interfacing. The 11401 or 11402 Digitizing Oscilloscope can be connected to a production IC tester host to aid in calibration or verification of pin electronics and parametric measuring units. The same can be done with VLSI verification systems, both as a means of system qualification and as a means of adding automated measurement power for device characterization.

To look at another application, the 11401 or 11402 can be driven by a laser trimmer through either the RS-232C or GPIB interface. The measurement power and speed of the 11400-Series can be used to provide dynamic functional tests which are sensed by the host computer, resulting in automatic trimming of hybrid circuits.

Want to know more?

As you can see, these new instruments are extremely flexible and powerful. While they're so easy to use that anyone can be making measurements in minutes, they contain measurement power that may take years to fully tap. This article only touches the surface in describing the capabilities of the 11401 and 11402 Digitizing Oscilloscopes. If you would like to know more about what they can do to revolutionize your measurements, contact your local Tektronix Sales Engineer or representative and ask for a videotape preview or a hands-on demonstration. Or check the appropriate box on the **HANDSHAKE** reply card for a brochure. 

With appreciation to David White, Tektronix Laboratory Instrument Division Marketing, for technical support in preparing this article.

Select your performance with 11000-Series plug-ins

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Tektronix, Inc.

Ever since introducing the plug-in concept to oscilloscopes in 1954, Tektronix has built upon this feature to provide performance, expandability, and a guarantee against obsolescence. The new 11000-Family is no exception. In the tradition of the 500-Series and the 7000-Series, the 11000-Family brings plug-in flexibility and expandability to new levels of both hardware and software modularity. This means long-lived products that can be adapted or expanded to meet future needs as well as present applications.

A new concept in plug-ins

Virtually all control of the 11000-Family plug-ins is accomplished through the mainframe, either manually or over the IEEE-488 (GPIB) or RS-232C bus. The only control on the amplifier plug-ins is a single pushbutton for each channel. This button is used only to turn the display of the associated channel on and off. Even when not selected for display, the input signal is still available for use as a triggering signal.

Control for all plug-in functions is through the touch screen menus and the main control knobs on the mainframe (see **Tektronix redefines the oscilloscope** for details). This includes not only selection of a channel for display, but also input coupling, deflection factor, trace positioning, vertical offset, and other plug-in dependent selections.

Due to the unique trace sequencing scheme in the 11000-Family, any of the plug-in channels can be used in more than one trace. For example, a given channel can simultaneously be selected for display by itself, for display in combination with another channel — either added or subtracted, used as a component of an X-Y trace, and as a triggering signal as well.

Each input channel on the amplifier plug-ins uses the new TEKPROBE® interface (Figure 1). This interface allows the mainframe to supply power to active probes, to sense the type (and with some probes, the serial number) of the probe, to supply offset voltage to probes so equipped, to detect activation of the probe's ID pushbutton, and to provide other communication between probe and mainframe as appropriate to the type of probe. A serial data line in the TEKPROBE interface provides the means for a high level of communication with current and future special purpose probes.

Precision offset

All of the 11000-Series plug-ins except the 11A71 use the same proprietary Tektronix-made single-IC amplifier. This integrated circuit is essentially a single-channel plug-in on a chip (see sidebar **Single-chip amplifier powers 11000-Series plug-ins**).

One of the outstanding features of this IC is the ability to accept DC offset voltage of up to one volt even at the highest sensitivity. This results in an effective screen height of 2000 divisions to allow measurement of minute signal variations at the extremes of relatively large signals or which are riding on DC levels. The DC offset also allows the measurement of signal levels to considerably better than 1% in most cases. Resolution of the DC offset voltage is one part in 80,000 which is equivalent to more than 16 bits of digital resolution.

Excellent overdrive recovery

Overdrive occurs whenever an input channel is driven substantially out of its linear range. The 11A32, 11A33, 11A34, and 11A52 have excellent overdrive recovery characteristics — the time it takes for the trace to return to equilibrium after a large input step. Overdrive recovery time for these plug-ins is on the order of tens of nanoseconds as opposed to milliseconds or microseconds with many other oscilloscope vertical amplifiers.

These excellent overdrive recovery specifications coupled with the ability to add 1000 or more divisions of vertical offset to waveforms provide some unique measurement resolution capabilities. For example, you can accurately measure millivolts of overshoot within 20 to 50 nanoseconds of the transition of a several-volt pulse (exact overdrive recovery time varies with plug-in). By adding up to ±1000 divisions of vertical offset (±8000 divisions with the 11A33), you can view only the overshoot area. Now, you can set the vertical deflection factor in the millivolt range rather than in the volts range required to display the pulse without offset. And the fast overdrive recovery time allows you to see the overshoot that is normally obscured in the pulse transition due to slow recovery time. Precise measurement of settling time is now possible because of this new level of performance.

Say goodbye to the "Uncal Blues"

Has this ever happened to you? You've just finished making a very complex and tedious series of measurements. You feel good that the job is done, but just to be safe you make one final check of the control settings. And then your world caves in! You notice that the variable control was out of the calibrated detent position and all those measurements are worthless. There's nothing to do but to start over again — if you can reproduce the experiment.

With the new 11000-Family, this will never happen again. But this problem wasn't solved by removing the ability to make measurements between the primary 1-2-5 sequenced steps. Instead, these new scopes provide calibrated settings in increments of 1% which function the same as a variable control, both vertically and horizontally. Except, you're always calibrated — even when the deflection factor reads, for example, 186 millivolts/division.

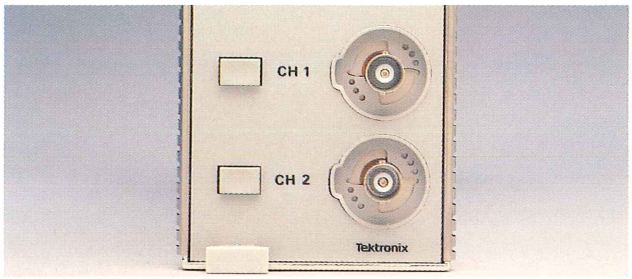


Figure 1. *TEKPROBE® interface provides signal connection (via BNC) as well as offset voltage, ID sensing, other probe communication, and power to active probes.*

Another advantage of the calibrated settings between the major steps is that you can easily set the vertical deflection for a full screen display and still be calibrated. This gives maximum accuracy when making precise measurements. Or, you can set the horizontal timing so a complete cycle covers all 10 divisions (or any increment in between) for easy timing comparison measurements.

Expandable for the future

A plug-in oscilloscope offers two major advantages — current flexibility and future expandability. Current flexibility allows you to choose just the vertical performance you need: One day, three channels at 1 GHz; the next day, eight channels at 300 MHz; on another day, four channels at 600 MHz plus one channel at 150 MHz differential, etc. You can share plug-ins between systems in your facility, thereby saving costs while still having access to the performance you need for special measurements.

The plug-in oscilloscope also offers future expandability — the ability to change the system configuration as your measurement needs change. You can buy only the plug-ins you need today and then add additional plug-ins later as the need arises. And in the tradition of the 500-Series and 7000-Series, Tektronix will introduce future plug-ins to keep the 11000-Family current with state-of-the-art measurements.

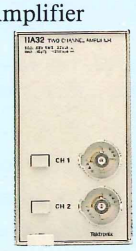
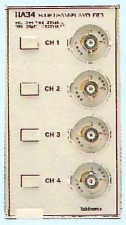
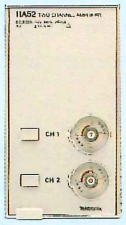
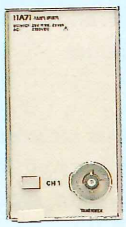
The plug-in family

Although the 11000-Series plug-ins look much the same from the front panel, each has unique performance characteristics. The sidebar **New 11000-Series plug-ins** provides a summary of the major characteristics of each plug-in along with their bandwidth/risetime specifications when used in each of the new 11000-Series mainframes.

For more information

Information on each of these new plug-ins is included in the 11300- or 11400-Series brochures. Or contact your local Tektronix Field Office or sales representative for specific details.

New 11000-Series plug-ins

Plug-In	Description	Bandwidth/Risetime			
		11301	11302	11401	11402
11A32 Two Channel Amplifier 	Dual-trace plug-in with switchable 50 ohm or 1 megohm input impedance. Two four-pole (24 dB/ octave) bandwidth filters (100 MHz and 20 MHz) are available per channel to reduce unwanted high-frequency noise. High-resolution DC offset provides a resolution of 25 microvolts and range of ±1.0 volt (equivalent to 16 bits).	300 MHz 1.2 ns	350 MHz 1 ns	350 MHz 1 ns	400 MHz 875 ps
11A33 Differential Comparator 	Single-channel differential comparator plug-in with high common-mode rejection ratio and fast overdrive recovery. Input impedance is switchable between 50 ohms, 1 megohm, and 1 gigohm. Calibrated DC offset of ±8 volts at maximum sensitivity of 1 mV/div provides an effective screen height of 16,000 divisions for very high resolution and high accuracy measurement of DC signal components. Built-in comparison voltage (V_C) allows precise measurement of the fine details on very large signals with unprecedented accuracy and resolution.	150 MHz 2.4 ns	150 MHz 2.4 ns	150 MHz 2.4 ns	150 MHz 2.4 ns
11A34 Four Channel Amplifier 	Four-trace plug-in with switchable 50 ohm or 1 megohm input impedance. Two four-pole (24 dB/ octave) bandwidth filters (100 MHz and 20 MHz) are available per channel to reduce unwanted high-frequency noise. High resolution DC offset provides a resolution of 25 microvolts and range of ±1.0 volt (equivalent to 16 bits).	250 MHz 1.4 ns	250 MHz 1.4 ns	300 MHz 1.2 ns	300 MHz 1.2 ns
11A52 Two Channel Amplifier 	Dual-trace high-speed plug-in with 50-ohm input impedance and good VSWR and overdrive recovery. Two four-pole (24 dB/octave) bandwidth filters (100 MHz and 20 MHz) are available per channel to reduce unwanted high-frequency noise. High-resolution DC offset provides a resolution of 25 microvolts and range of ±1.0 volts (equivalent to 16 bits).	350 MHz 1 ns	400 MHz 875 ps	500 MHz 700 ps	600 MHz 540 ps
11A71 Amplifier 	Provides highest bandwidth currently available for the 11000-Series. Input impedance is 50 ohms only. DC offset is used to position the trace in units of 0.25 division (coarse) and 0.025 division (fine). Total offset range is 10 divisions at all sensitivities.	400 MHz 875 ps	500 MHz 700 ps	500 MHz 700 ps	1 GHz 350 ps

Single-chip amplifier powers 11000-Series plug-ins

At the heart of the 11A32, 11A33, 11A34, and 11A52 is a Tek-made proprietary single-chip amplifier. This amplifier is essentially a high-performance differential plug-in on a chip and is responsible for the excellent input characteristics of these 11000-Series plug-ins. Using a common chip for each of these plug-ins not only reduced development costs but has also provided matched performance across the plug-in line.

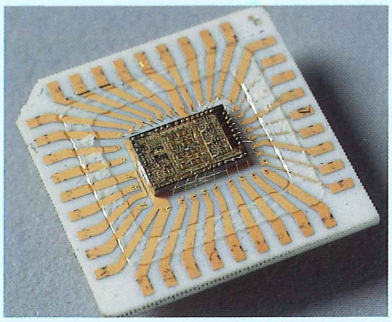


Figure A. *Single-chip amplifier before it is encased.*

Figure A shows the single-chip amplifier before it is encased. It was designed using VLSI techniques and has 733 transistors, 90 Schottky barrier diodes, 537 resistors, and 90 capacitors.

A block diagram representation is shown in Figure B. It is essentially a differential amplifier with a variety of control-voltage inputs and multiple outputs. The input signal from the plug-in input connector is applied to the positive input and offset-control voltages are summed into the negative input. Three differential outputs result — signal out, trigger out, and auxiliary out.

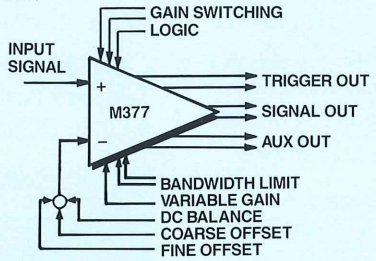


Figure B. *Simplified block diagram of single-chip amplifier used in the new 11000-Series plug-ins.*

Six coarse deflection-factor settings between 1 millivolt/division and 50 millivolts/division are controlled by the three Gain Switching Logic inputs. Precise gain is set by a controlled voltage input on the Variable Gain line. Two Bandwidth Limit inputs allow a choice of bandwidth.

The Variable Gain, DC Balance, Coarse Offset, and Fine Offset voltages are supplied by the mainframe. These voltages are carefully regulated in the mainframe to allow calibrated variable and offset operation.

With thanks to John Addis, Tektronix Laboratory Instruments Division Engineering, designer of this IC.

On-site service available for 11000-Series

Peter Loeb
Instrumentation Service Product Marketing Manager
Customer Service Group
Tektronix, Inc.

Tektronix has a long history of servicing what it sells. Even before service became a part of our business, Tektronix Field Engineers carried kits of spare parts with them and made repairs and adjustments right at the customer's bench.

We have always believed that the Tektronix reputation for excellence depends on three equally important elements — innovative design, product quality, and reliable service — and that the third is often a determining factor in the long-term value of the customer's investment.

To us, total service means providing the resources to assure that the Tek products you buy start up without problems — and stay up and operating properly without interruption. We know that unplanned downtime is at the least an annoyance, and can often be extremely expensive as well — like when it shuts down production or delays completion of a project. Disastrous!

So we're offering a totally new service package for the 11000-Series — On-Site Warranty Plus — to help protect your initial investment and manage your ownership costs.

On-site warranty plus

In essence, Tek's new Warranty Plus programs upgrade the standard warranty that comes with each Tektronix product. For the new 11000-Series oscilloscopes, which feature systems configurability and leading-edge technology, we've added even more.

Option S0, On-Site Installation, provides the following services by Tektronix Service personnel: Setup instrument, add field installable options, connect peripherals, verify correct operation and performance, and provide an orientation on instrument operation for the user.

Option S1, On-Site Service, upgrades and converts the one-year carry-in product warranty to one year of on-site service. This includes a minimum of one visit for product verification, plus calibration, maintenance, repair, and modifications as needed. With this option, you are assured of much faster response time from the Tektronix Service Center — usually within one working day. Furthermore, the warranty follows the individual product by serial number, even in mixed systems, to provide greater protection for your systems applications.

The On-Site Warranty Plus upgrade is sold by the 11000-Series sales force so that you can purchase both product and service/maintenance as a package. The upgrade provides eight-hour (one working day) response time within 75 miles of designated Tektronix U.S. Service Centers strategically placed to provide convenient nationwide support. On-site service is provided by specially trained service specialists who have access to Tek's $35 million parts inventory available throughout the 48 contiguous states.

On-Site Warranty Plus is Tek's customer-responsive program to provide maximum long-term value to 11000-Series customers.

Other service/maintenance options

For customers who choose not to purchase the S-Option On-Site Warranty Plus when they buy 11000-Series products, Tektronix also offers a secondary product support strategy. Service can be purchased on demand, either on-site or at a U.S. Tektronix Service Center, on a per-call and per-incident basis. The cost is $95/hour (U.S. dollars) plus parts. For on-site calls, charges include travel time/expenses.

Other maintenance agreements are also available, with prices determined by such factors as service location, required response time, and duration of service agreement.

Tek service for the best performance

In addition to its many performance features, the 11000-Series is designed for serviceability. Its self-diagnostic capability helps our service specialists locate problems quickly. Repair at the module or board level makes it easier to get your equipment back up and running in the least possible time.

For your best deal on 11000-Series service and maintenance, we recommend On-Site Warranty Plus — both for maximum up-time, and for best cost-effectiveness when compared to shipping instruments back and forth for service. Our on-site service specialists are trained specifically to help you — our aim is to service both the product and the customer.

For information on Tektronix service, call your local Tektronix Field Office or sales representative and ask for the location of the nearest Tektronix Service Center.

Probes to match 11000-Series performance

Ken Carlson
High Performance Probes Project Manager
Accessories Division Engineering
Tektronix, Inc.

New family of probes designed for use with the Tektronix 11000-Series. Left, P6231 DC to 1.5 GHz 10X Variable Offset Probe; center, P6134 DC to 300 MHz 10X Passive Probe; right, P6135 DC to 150 MHz 10X Passive Differential Probe.

In designing a new oscilloscope system, the attention and glamour is usually focused on the mainframe itself — the display, the vertical amplifier, the digitizing system, etc. An often overlooked, yet essential, part of the system is the method of connecting the signal-under-test to the oscilloscope. Unless the integrity of the signal is maintained as it is passed to the oscilloscope, all the effort put into high-performance mainframe design is essentially wasted. As a result, Tektronix designed a series of new probes to match the performance of the 11000-Series. These probes not only provide superior signal integrity but also provide new operating convenience.

First of a family

These probes are the first in a family of high-performance probes designed for use with 11000-Series plug-ins. They feature a small, low-mass tip along with an extremely flexible, kink-resistant cable. A unique ground lead system is incorporated to provide versatile grounding methods (Figure 1). The short swivel ground lead (Z lead) is extremely useful when probing high-frequency circuitry where short lead length is essential. The ground lead with microhook and alligator clip are tailored for ease of use in a wide range of applications.

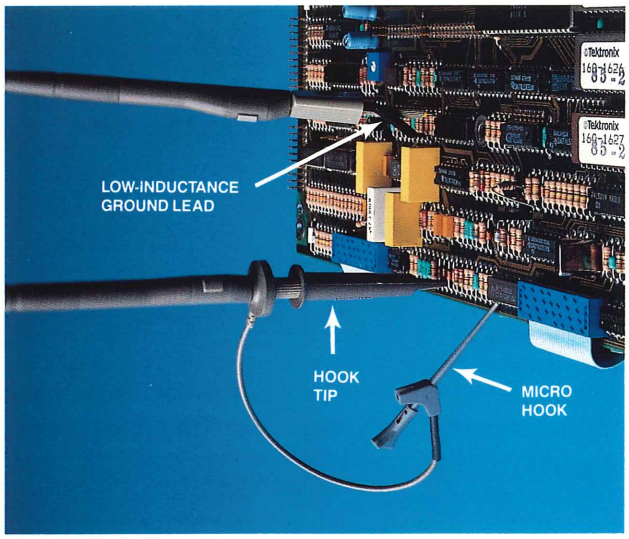


Figure 1. *New probe family offers a variety of grounding methods.*

These probes are also compatible with all subminiature accessories such as the KLIPKIT — an adapter to allow convenient and safe connection to in-line integrated circuits. The probe family also incorporates a subminiature-to-miniature probe tip adaptor to allow use of the probe accessories that Tek provides for its miniature probe product line.

A "smart" probe connector

Each channel on 11000-Series plug-ins features a new TEKPROBE® interface connector (Figure 2). This interface provides a variety of features to make measurements with a 11000-Series system easy and convenient. Most important, the connector provides signal input connection via a standard high-frequency BNC connector. The added functionality of the TEKPROBE connector does not interfere in any way with normal signal connection.

A series of contacts surrounding the signal-input connector makes this probe interface "smart." When a suitably equipped probe is attached, the TEKPROBE interface provides the following features (as implemented by the probe):

- The interface supplies all the power needed to support active probes. This eliminates the need to check if the mainframe has the probe power option or the need to purchase an external power supply. And since each input connector provides probe power, you can use as many active probes as you have inputs without the need to add auxiliary power supplies.

- The interface allows data communication between the probe and scope. This feature is unique in that the scope reads the data from the probe and sets up the scope for pro-

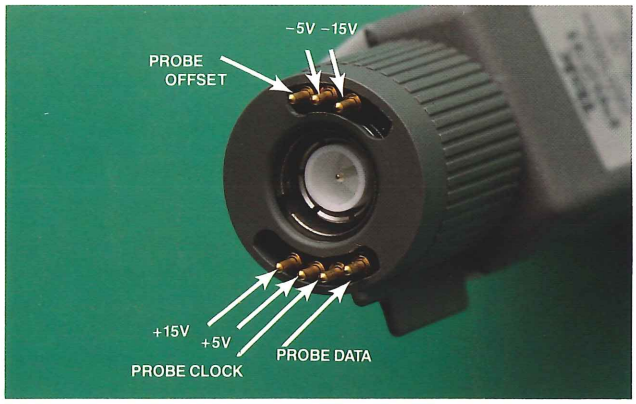


Figure 2. *New TEKPROBE® connector on each 11000-Series input channel provides signal connection, power for active probes, offset voltage, plus two-way communication between the probe and the mainframe.*

per system operation when the probe is placed on the scope. This includes the selection of internal 50-ohm termination for inputs with selectable input impedance, correction of attenuation and offset scale factors, and even providing the correct units to be displayed on the CRT.

- The interface provides a channel for transfer of calibrated variable offset or bias voltage to active probes. This allows measurement with a minimum of loading effect on the circuit-under-test (P6231).

- For advanced system implementations, the TEKPROBE connector serves as a two-way serial data communication channel between the probe and mainframe. This opens the door for future "smart" probes with functions not even imagined today.

One-button measurement power

Each of these probes feature an "Identify" button on the probe head which allows the user to control functions within the 11000-Series mainframe. This can be as simple as highlighting and turning on the selected channel. Or the ID button can be programmed to initiate an "autoset" routine to provide a usable trace with the press of a single button at the signal source. An additional function that can be selected is the execution of a predetermined sequence of function steps or the issuance of an SRQ command to an associated controller. Functionality of the ID button is selectable from the UTILITY menu on the mainframe.

Three new probes

The P6134 is a 300 MHz high-impedance passive voltage probe designed to work into 1 megohm inputs on the 11A32/34 Amplifiers. Passive probes like the P6134 are more rugged, withstand more mechanical and electrical abuse than other types, and because of their simplicity, are easier to maintain. For general purpose use, the P6134 is the best choice.

The P6135 is a differential-probe pair specifically designed for the 11A33 Differential Amplifier plug-in. This probe is mechanically similar to the P6134. However, it has a specially designed cable and additional circuitry for improved common mode performance.

The newest active probe in the family is the P6231 Variable Offset Probe. This probe is a 10X, 450-ohm 1.5 GHz probe designed to work into 50-ohm plug-ins such as the 11A52 Two Channel Amplifier and the 11A71 Amplifier. This probe takes full advantage of the TEKPROBE interface connector to make active-probe measurements easy and convenient. For example, power to operate the probe is drawn from the interface connector. Also, when the probe is attached to an amplifier with switchable input impedance, it automatically switches the input to 50 ohms. Another feature is the ability to provide offset to the probe tip from the mainframe. This is important because the P6231 makes extensive use of this feature to reduce the loading effect on the circuit-under-test.

Watch those grounds

These probes are all designed for high bandwidth applications. Care must be taken when measuring high-frequency signals to maintain signal integrity. The ground-return path (or ground lead) to the probe can have a major impact on the fidelity of the displayed signal. The ground lead introduces inductance into the measurement path that causes a damped-oscillation (ringing) in the displayed signal. To minimize this effect, the user must make sure the ground-return path (ground lead) is as short as possible. The best demonstration of this effect is shown in Table I. This table shows the degradation of P6231 performance with various types of ground leads.

TABLE I

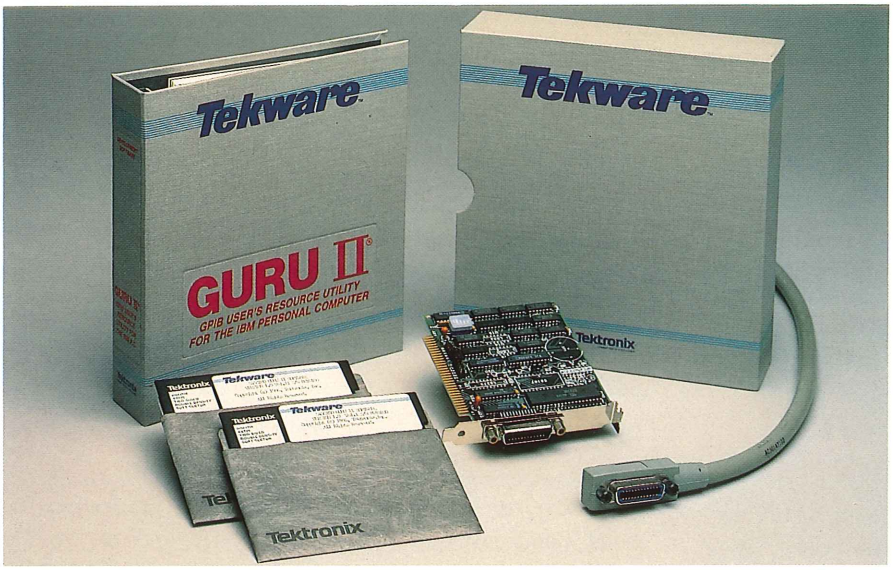
Typical Performance Effects of Different Grounding Configurations

Grounding Method	Risetime	Bandwidth (calculated)
Probe tip-to GR adapter	230 picoseconds	1.5 GHz
Low-inductance lead	440 picoseconds	800 MHz
6.5-inch lead	1.0 nanosecond	350 MHz
No ground lead	16 nanoseconds	22 MHz

For Information

To find out more about these new probes, contact your local Tektronix Field Office or representative. For a data sheet describing these probes, check the appropriate box on the **HANDSHAKE** reply card. Tektronix probes and accessories can also be ordered from the Tektronix National Marketing Center, 1-800-426-2200 (in Oregon call 627-9000 collect). And be sure to tell them you saw it in **HANDSHAKE.**

GURU II — an improved link between the IBM PC and GPIB instruments



GURU II+ provides a complete GPIB interfacing solution in one package — GPIB interface card, interfacing software, tutorial manual, and application routines.

About a year ago Tektronix introduced GURU — the GPIB User's Resource Utility (see the Spring 1985 **HANDSHAKE**). This has proven to be a popular tool kit to allow an IBM PC (or compatible) to be used as a GPIB-based instrument controller.

Now, Tektronix introduces an updated and improved package — GURU II and GURU II+. GURU II/+ provides all the functionality of the original GURU package plus:
- A new digitizer program with pulse parameter routines.
- Compiled version for increased system speed.
- National Instruments PC-2A GPIB card — an updated version of the original PC-2 card.

GURU II and GURU II+ are identical except that GURU II+ includes software, manual, GPIB cable, and GPIB interface card while GURU II includes software and manual only.

Why use GURU II?

GURU II+ is a complete GPIB interfacing solution in one package. It includes the GPIB interface card, interfacing software, tutorial manual, and application routines.

For those not familiar with GPIB operations, the GURU II manual contains an overview of the interface and a complete tutorial on setting up an instrument control system. The GURU II manual and example programs cover a span from a beginner's tutorial, through system program development with BASIC, to advanced uses with included application routines.

If you are just getting started in GPIB instrument control, GURU II can save you endless hours of frustration and dead ends. Yet GURU II is open-ended for those with GPIB experience. Its variety of utility routines and application examples allow you to progress quickly to more complex test and control operations.

Built-in application routines

GURU II provides a variety of application routines allowing the novice programmer as well as the sophisticated user to reduce the amount of time expended in developing test software. Routines provided include:

Test program generator (TPG) allows users to generate a specific program that runs a test sequence without writing a single line of BASIC code.

Digitizer acquisition routine (TekDIG) allows for fast acquisition and storage of waveforms for future analysis. Also provides utilities for displaying and printing waveforms from the computer display.

Test and measurement subroutines (SUBS) allow the user to program any GPIB device by simply entering the appropriate number from a menu. These subroutines are building blocks for user program development.

Pulse parameter routines (DIGPULSE) allow a user to make a variety of measurements on acquired waveforms including risetime, falltime, min/max/mean, RMS, voltage, and histogram. You can "zoom" in on a particular section of a

plotted waveform to examine it in finer detail using any of the pulse parameter routines.

Export capability allows data acquired by GURU II to be exported in a file format compatible with many PC-based application programs such as Symphony, Framework, Lotus 1-2-3, ASYST, etc. The data can then be graphed or processed in further detail using the functions available in these programs.

Application programs are provided to demonstrate system operation and programming. These include SCOPEVER to demonstrate use of the Tektronix CG 5001 Oscilloscope Calibration Generator, TRANTIME to measure risetime or falltime according to user-specified thresholds using the Tektronix 2445A/2465A Oscilloscope, and AUDIODEM to demonstrate the Tektronix AA 5001 Programmable Distortion Analyzer and SG 5010 Programmable Oscillator to make audio measurements and graph the results.

Increased system speed

GURU II offers compiled versions of TPG, TekDIG, and DIGPULSE along with the original interpretive BASIC versions. This results in greatly increased system speed — up to eight times in some applications. Source code for compiled versions of the application routines are also provided.

System requirements

The following minimum system configuration is required to run GURU II:

Required hardware:
- IBM PC, IBM PC/XT, IBM PC/AT, the COMPAQ family, and many compatibles.
- 256 Kbytes memory.
- Two double-sided, double-density disk drives (or single drive with hard disk).
- IBM Color Graphics Card or Hercules Graphics Card in a true IBM PC (Interpretive BASIC only with Hercules Card — not for compiled BASIC).
- Compatible graphics monitor.

Required Software:
- IBM PC-DOS, version 2.1 or higher (PC-DOS versions 2.0 to 3.1 for HBASIC on Hercules Graphics Card).

Optional Software:
- IBM BASIC compiler, version 2.0.

Ordering information

To order GURU II+, call the Tektronix National Marketing Center, 1-800-426-2200 (in Oregon call 627-9000 collect), and ask for S37G100 GURU II+. And be sure to tell them you saw it in **HANDSHAKE**.

NOTE

If you already have a National Instruments PC-2A or PC-2 GPIB interface card, you can order the GURU II manual and software only; order S37G110 GURU II.

Updates are also available for current owners of GURU V1.0 or V1.1; contact your local Tektronix Field Office, the sales representative for your country, or the Tektronix National Marketing Center for upgrade information.

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

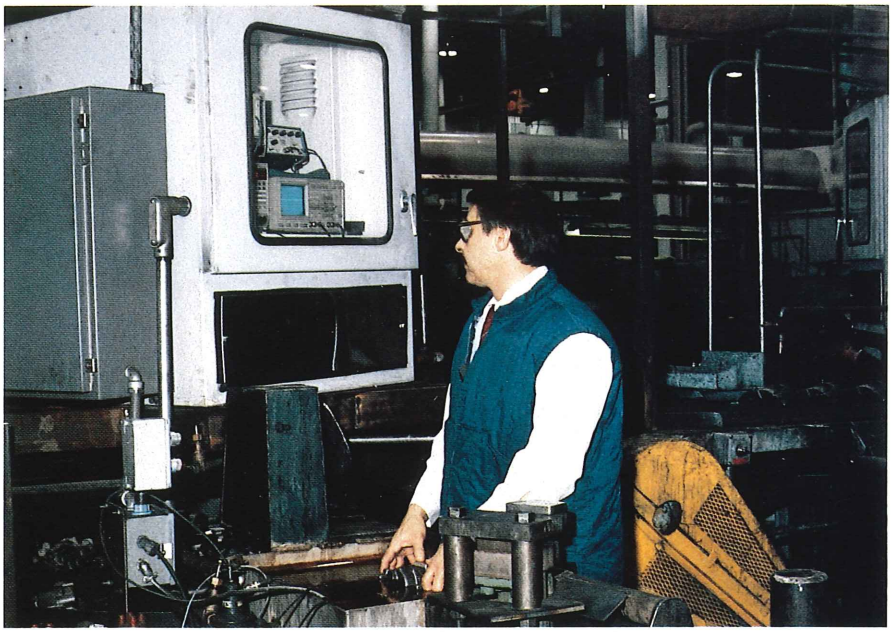
Digitizer selection chart

A selection chart listing the specifications of all digitizers currently available from Tektronix is included as a pullout in this issue. This pullout also includes a tutorial guide to choosing a digitizer.

If this chart has been removed or to get an additional copy of this chart, contact your local Tektronix Field Office or representative and ask for literature number 49W-6546. Or check the appropriate box on the **HANDSHAKE** reply card.

Zero defects through automatic ultrasonic testing of nodular iron castings

Scott Falconberry
Application Engineer
Detroit Field Office
Tektronix, Inc.



Test station for ultrasonic testing of nodular iron castings. Notice the test equipment installed in the environmental protection enclosure.

General ultrasonic and nodular iron concepts

Ultrasonic testing is one of the few nondestructive evaluation techniques that can detect flaws and irregularities substantially below the surface of a material. It is especially useful in determining characteristics of engineered materials. This article concentrates on a specific application — automated testing of nodular iron castings in a foundry environment.

It has been observed that sound has a relatively constant velocity through homogeneous materials. Since cast iron is not homogeneous, changes such as shape, size, and whether the cast part has been subject to heat treatment affects the velocity of sound through the part being tested.

Nodular iron, which has superior strength to gray iron (standard cast iron), is used to replace more expensive materials such as steel. The making of nodular iron is a complex process. Small amounts of silicon and magnesium are added to molten iron with precise timing. If the process is performed correctly, tiny spheroids (nodules) of graphite form, scattered homogeneously throughout the cast iron part. However, the process is not always perfect. As a result, all critical parts are tested for 100% verification.

Nodular iron offers significantly less resistance to sound than gray iron. In fact, the percent of nodularity of the graphite in the cast iron can be predicted quite accurately from sound propagation measurements.

Automatic ultrasound testing

In automatic testing, both the test time and the accuracy are prime concerns. Since high throughput is desirable for better productivity, the length of the test cycle itself may well determine if producing the part is cost effective. The testing must also be thorough, since many of the parts being tested are critical to the safe operation of the machine on which they are installed. Desired testing time of a cast nodular iron part in this application was determined to be two to three seconds each.

The automated environment offers many challenges in the testing of nodular iron. The usual procedure in ultrasonic testing of parts is to place the part in a water bath between two crystals. One crystal is pulsed to emit an ultrasonic burst. The second crystal receives the pulse after it passes through the part. Figure 1 shows a diagram of the pulse path along with an idealized waveform.

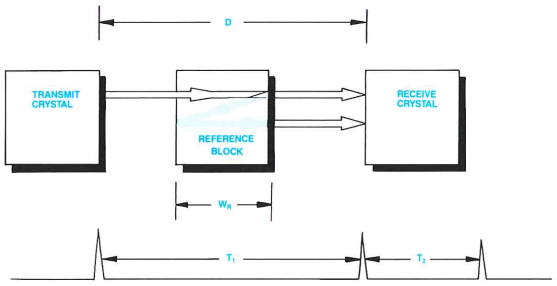


***Figure 1.** Diagram of the pulse path through a reference block and idealized waveform sensed at the receiving crystal.*

To measure nodularity, the distance (D) between the crystals must be known along with the sonic velocity of the water in the tank (V_W). These values are then used as constants to calculate the size of a part under test and the sonic velocity through the part. One way to automatically measure D and V_W is to put a reference block of known size and composition into the fixture. The system then pulses the transmitting crystal and measures T_1 and T_2 (Figure 1). T_1 is the time required for the pulse to travel from the transmit crystal through the reference block to the receive crystal. T_2 is the additional time required for a reflected pulse, which must traverse the reference block twice, to reach the receive crystal. Time T_3 — the time required for the pulse to travel the distance between the two crystals with the reference block removed — is also measured.

Time periods T_1, T_2, and T_3 can be used to calculate both distance (D) and water velocity (V_W).

First consider T_1 and T_2. The time T_W that the ultrasonic pulse spent in the water between the reference block and crystals can be extracted from T_1. Subtract the time the pulse spent in the reference block, $T_2/2$ from T_1 (divide T_2 in half because the pulse transverses the block twice). This gives the formula:

$$T_W = T_1 - T_2/2 \quad [1]$$

Distance D can be written as the product of the time the pulse spends in the water and the water's sonic velocity plus the measured width of the reference block, W_R:

$$D = T_W * V_W + W_R \quad [2]$$

or:

$$D = (T_1 - T_2/2) * V_W + W_R \quad [3]$$

Another equation for D can be written using T_3:

$$D = T_3 * V_W \quad [4]$$

We now have two equations containing the same two unknowns (D and V_W). They can be solved for the velocity of the pulse in water (V_W) by subtracting equation [3] from equation [4] to yield V_W in terms of T_1 and T_2. This process is:

$$\begin{aligned} 0 &= T_3 * V_W - (T_1 - T_2/2) * V_W - W_R \\ W_R &= (T_3 - T_1 + T_2/2) * V_W \\ V_W &= W_R/(T_3 - T_1 + T_2/2) \end{aligned} \quad [5]$$

V_W can now be plugged back into equation [4] to find D. The values for V_W and D are used as constants to test parts.

Testing a part

To test a cast nodular iron part, the part is placed in the tank in place of the reference block. The same measurements are performed to determine T_1 and T_2. The width of the part (W_P) is calculated using the previously determined values for D and V_W as constants.

$$W_P = D - (T_1 - T_2/2)V_W \quad [6]$$

Finally, the velocity of the pulse through the part can be calculated from the known values using the formula for velocity:

$$V_P = W_P/(T_2/2) \quad [7]$$

where:

V_P = velocity through the part
W_P = change in distance
$T_2/2$ = change in time

If the reading received for the width of the part or the velocity of the pulse through the part is incorrect, either the part was improperly cast (e.g., wrong dimensions) or the graphite did not nodularize as expected yielding undesirable ultrasonic characteristics.

In practice, environmental parameters of the test set such as placement of the crystals, temperature of the water, contaminants in the water, and other factors play a major role in whether or not a part passes the nodularity check. The automated system as implemented only checks the velocity of sound through the water and through the part. If either of these tests fail repeatedly, the environmental parameters should be checked thoroughly before a series of parts are rejected.

Speed and accuracy

For this automated foundry application the length of the test cycle desired was less than two to three seconds. This includes recognizing that a part is in the tank, testing the part, comparing it to predetermined limits, recognizing that the part is out of the tank, testing the propagation time through the water, and indicating the pass/fail condition of the test. Accuracy of 0.1% for the velocity measurement is not uncommon.

A Tektronix solution for automatic ultrasound applications

The solution for this application consists of hardware, software, and test stand fixtures. The hardware was supplied by Tektronix. The software was written by a Tektronix Applica-

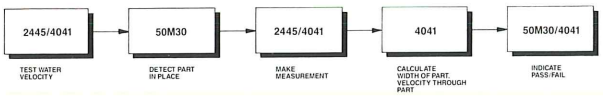


Figure 2. Functional block diagram by events.

tion Engineer with input from the site personnel under a Tektronix service called Technical Assistance Service (see sidebar **Technical Assistance Services provides the solution**). The test stands were provided by the manufacturer of the nodular iron parts.

The functional block diagram in Figure 2 is arranged in order of the main events in a typical test, relating these events to the equipment used. Figure 3 shows how the equipment is connected.

A look at the Tektronix hardware

First, let's look at the hardware used. A modified Tektronix 2445 Oscilloscope (MOD YF) with Option 06 (counter/timer/trigger) and Option 10 (GPIB) is used to display the ultrasonic burst waveforms and measure the parameters. (See the sidebar **2445A Oscilloscope provides semi-automatic measurements** for details on the 2445.) The 2445 counter/timer/trigger (CTT) also measures the time delay between the original pulse and its echo. MOD YF is a custom modification which allows the 2445 CTT to simultaneously make both delayed sweep and delta time measurements.

The Tektronix 4041 System Controller manages all the system resources as well as performing calculations on the acquired parameters. The Tektronix MI 5010 Multifunction Interface with a 50M30 Digital I/O Card is used for relaying information to and from the test fixture on part presence and test results. The General Purpose Interface Bus (GPIB) is used for all system device control and communications.

A Tektronix 4105 Graphics terminal and a Tektronix 4644 Dot Matrix printer were used for system development purposes. These instruments are not required for operation but are required for further system development or modification.

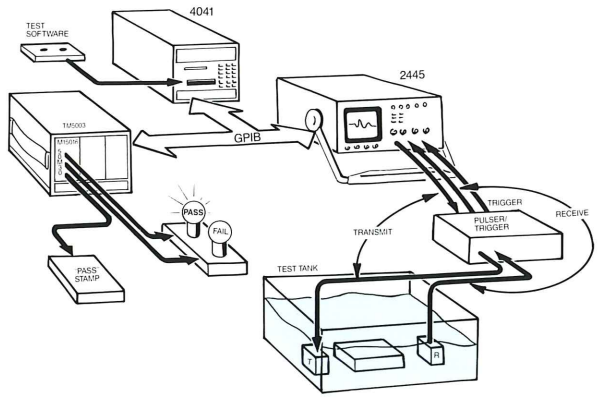


Figure 3. Connection diagram for equipment used for nodular iron test system.

Software—the "glue" that holds the system together

The "glue" for this system is the software. A flow diagram of the program written to automatically test cast parts for nodularity is shown in Figure 4. Following is a brief description of its main features.

Step 1. Initialize system. Since the instrumentation is all provided by Tektronix, all components conform to the Tek Standard Codes and Formats. For example, a simple command such as "init" sent to each instrument returns that instrument to a known state.

Step 2. System calibration — measure environmental factors. Without a part in the tank, the system operator adjusts the 2445 Oscilloscope to display the transmitted pulse and the received pulse. The 4041 System Controller then configures the 2445 CTT via the GPIB to the delay mode which computes the time from the trigger on the "A" sweep to the trigger on the "B" sweep. From this measurement, the velocity of the pulse through water can be calculated using time T_3.

The oscilloscope is then put in the "B TRIGGER MODE: RUN". This allows the operator to move the intensified "B" sweep in much the same manner as cursors. When positioned just before the peak of the first echo, the operator presses a front-panel button on the 4041.

The 4041 sends a command to the 2445 to change the oscilloscope to "B TRIGGER MODE: TRIG" operation which causes the B sweep to find the next occurrence of a predetermined voltage level. The delay from the A trigger to the B trigger is then measured and sent to the controller.

Step 3. System calibration — measure reference block. The operator places a reference block in the tank and adjusts the oscilloscope until the transmitted pulse and two received pulses are present on screen.

The same procedure used to obtain time T_3 is used to compute T_1 and T_2. The operator moves the intensified zones to the peaks of the two received pulses and presses a front-panel button on the 4041. The 4041 then sends a code to the 2445 which puts it in the "fast" mode. That is, two measurements are calculated and sent over the GPIB. The first measurement, T_1 is performed exactly as T_3 in step 2. Also measured is time T_2 between the first received pulse and the second. This is called the "delta" measurement. In order for the 2445

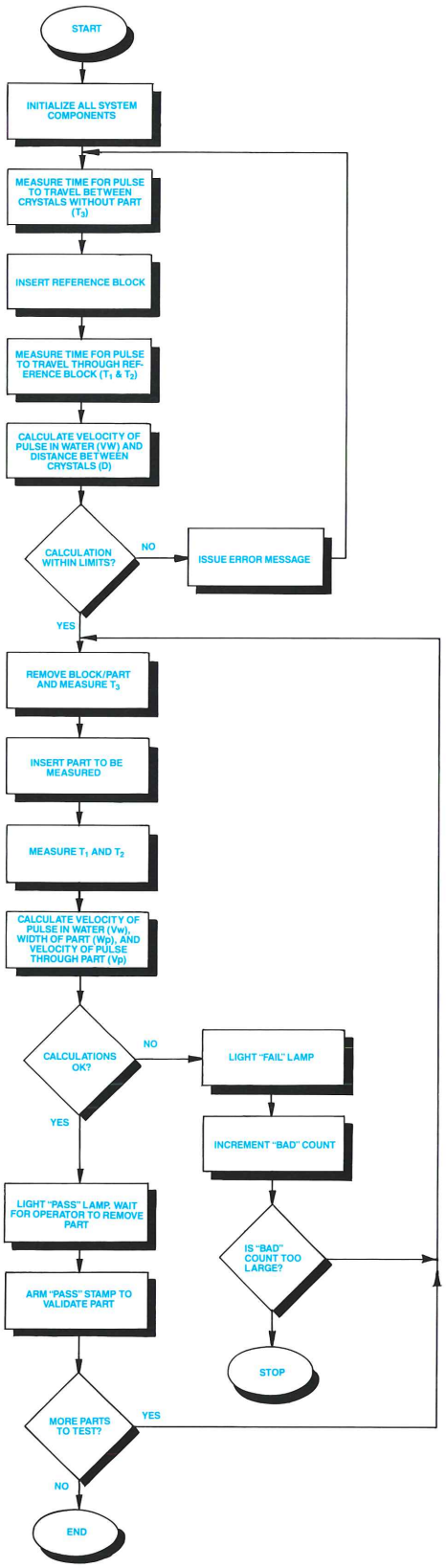


Figure 4. *Flow diagram for nodular cast iron test program.*

to make both measurements at the same time, MOD YF must be installed. The delay from the transmitted pulse to the first received pulse (T_1) is sent along with the delta measured from the first to the second received pulse (T_2).

From the measured values, the velocity of the pulse in water (V_W) and the distance between crystals (D) is calculated.

Step 4. Measure part. Replace the reference block with the part to be measured and repeat Step 3. Calculate velocity of the pulse through the part (V_P) and width of part (W_P).

Step 5. Compare results to limits. Compare the results obtained in Step 4 with predetermined limits stored in the 4041.

Step 6. System verification. Check velocity of the pulse in water (without part in test tank) to ensure that the water temperature has not changed appreciably, major contaminants have not been introduced, or the crystals have not been moved inadvertently. If out of tolerance, halt test and signal system operator.

Step 7. Give pass/fail indication. Based on the values obtained in Steps 5 and 6, the 4041 gives the proper instructions to the 50M30 Digital I/O card. The 50M30 then provides a TTL-level output for pass/fail indication.

Step 8. Activate stamp if part is good. If the part passes, arm the stamp to provide a test record on the part itself.

Step 9. Test next part. Return to step 4 and start process over again to test the next part.

Added features and benefits

The Tektronix 4041, 2445 CTT, and the 50M30 offer many unique advantages. Since the 4041 is programmed in structured BASIC, the end user can tailor the program to exactly fit system needs. In the foundry setting, setups can literally be changed over night to produce a new part. The test program must be changed quickly and easily to match the specifications of the new part. Because the 4041 BASIC language is highly structured, new modules can be written efficiently and embedded easily in the test program.

The 4041 front panel can also be reassigned so it accepts calls to subprograms rather than numeric input. This can allow an operator to approach a test stand, interrupt the current test at any point, and do a completely different set of tasks without totally aborting the program. Such routines as water-velocity calibration, inputting new limits, checking the number of good parts vs bad, etc., can be done at the touch of a button. Because all Tektronix GPIB equipment can be "locked out," system integrity can be preserved.

The DC-100 tapes used to store 4041 programs and data can easily be updated and/or moved from one test site to another. In addition, programs can be "burned" into PROMs and used in place of the tape if desired. This is particularly important in the harsh environment found in most foundries.

Having the program in PROM, safely stored inside the 4041 rather than on magnetic media can reduce errors caused by dirt or dust on the tape or tape drive.

In addition, the 4041 can be networked via RS-232C or GPIB. This allows several test stations to be controlled or queried from a centralized location. A typical use for this feature would be to gather data for statistical or quality control purposes. For example, all test stations in a foundry could be polled periodically to obtain such information as:

- Number of parts tested.
- Number of bad parts.
- Verification that system is inspected/verified as scheduled.

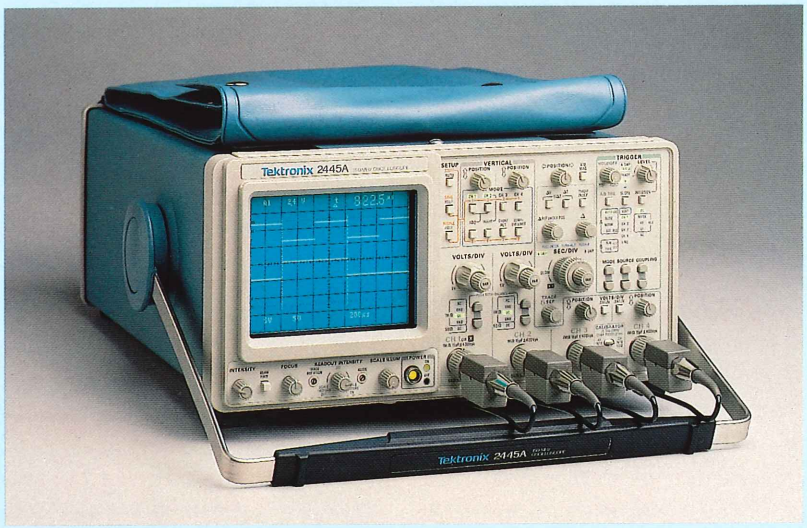
In summary

A programmable analog oscilloscope with precision counter/timer/trigger and GPIB options networked with a versatile instrument controller and application software can provide accurate, reasonably priced solutions for non-destructive test applications. This results in increased productivity and reduced component testing costs.

For further information on this application or any of the equipment used, contact your local Tektronix Field Office or representative. A copy of a test program which can be used as a foundation for developing your own test program can be obtained from the author.

The author wishes to acknowledge the assistance of Gordon Shank, Software Engineer, Portable Instruments Division, Tektronix, Inc., in developing this application.

2445A Oscilloscope provides semi-automatic measurements



Tektronix 2445A 150 MHz Oscilloscope provides a variety of automatic measurements.

Since this application was developed, the 2445 oscilloscope has been upgraded to an "A" model. In addition to all the features that made the 2445 the best choice for this application, the 2445A adds additional capability for even easier measurements — and at no added cost.

The 2445A 150 MHz Oscilloscope can be easily programmed to assist the scope operator in performing a complete sequence of measurements. Front-panel settings can be remotely set or changed with display prompting of messages to provide guidance for the operator. The results of voltage, time, frequency, phase, and ratio can be both displayed on the CRT and read over the GPIB (with Option 10).

In addition, Auto Set-Up scales the vertical, horizontal, and trigger systems to provide a stable, automatically triggered display of the probed waveforms. A Save/Recall utility saves and recalls up to 30 setups for automating repetitive measurement sequences. The counter/timer/trigger (Option 06) is ideal for automatic frequency, period, pulse width, and time-between-events measurements. The digital multimeter (Option 01) provides automatic digital multimeter tests and measurements. See **Analog scopes move into measurement automation** in the Fall 1986 **HANDSHAKE**, Vol 11 No. 3 for further details on the 2445A.

To find out more about the 2445A, contact your local Tektronix Field Office or representative. For a brochure, check the appropriate box on the **HANDSHAKE** reply card in this issue. The 2445A can also be ordered through the Tektronix National Marketing Center: 1-800-426-2200 toll-free (in Oregon call 627-9000 collect) and tell them you saw it in **HANDSHAKE**.

Technical Assistance Services provides the solution

This system solution was developed using a Tektronix service called Technical Assistance Services (TAS). The customer knew what needed to be done — the environment, what needed to be measured, and the tolerances required. Tektronix had the equipment and the know-how to make it work. Getting the two together provided a quick, thorough solution.

After initial investigation and a rough "demonstration" program that proved the feasibility of the proposed solution, the customer contracted for a block of TAS time to produce the system. The Tektronix Application Engineer (Scott Falconberry) worked with a measurement technician at the foundry site to develop the detailed, working program. Through the interchange and cooperation developed in this process, the customer received not only a working measurement system but a trained technician who could provide system maintenance and future modification if required.

Typical TAS services

Typical Technical Assistance Services include:

Installation assistance including pre-installation counseling, assistance in installing hardware or software, and installation verification. This helps to ensure that your system is installed and operational in a minimum amount of time.

Familiarization training which usually takes the form of a brief introduction to hardware basics, system interaction, or software utilization. It may be presented to individuals or groups. This is often the easiest way to acquaint users with important features of new systems or system components.

Interfacing assistance to help you with unusual interfacing challenges that require intimate knowledge of Tektronix hardware and software. This may include interfacing Tektronix system components to system components supplied by other vendors or to your own customized test fixtures or equipment.

Software assistance with the design and development of software required for your unique application. Software is often the most complex element of a system. Software assistance can substantially reduce your software development time and cost and help to ensure that your system fully uses the performance designed into each of its components.

Custom training tailored to your specific application, unique environment, or personnel needs. Training is designed and presented by a Tektronix Application Engineer and helps ensure that your system users are properly trained in all aspects of system operation.

Problem definition and debugging assistance to make your system software operate to its optimum potential. Even the most experienced programmer can make mistakes that take days to correct, or overlook features that can enhance system performance. Tektronix Application Engineers can help you trace and debug software and hardware/software interaction problems within a system.

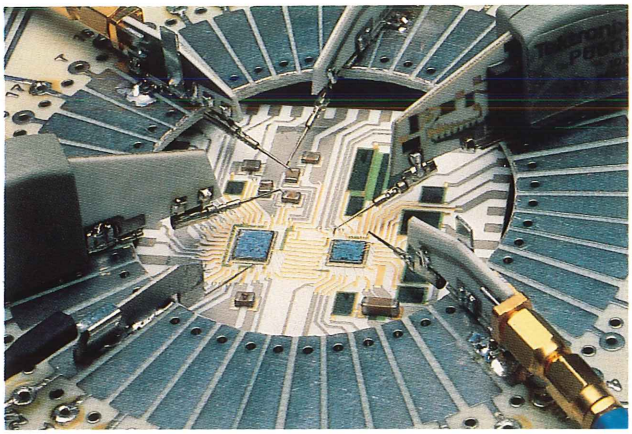
Application assistance providing expert consultation in signal acquisition and processing, specific measurement tasks, integrating Tektronix hardware into an existing process, and other specific application tasks. Tektronix Application Engineers can often suggest new problem solving approaches that can help you obtain maximum performance from your system.

Interested?

Technical Assistance Services may be purchased in one hour increments. Order part number 068-9080-00, Instrument Group Technical Assistance Services — 1 hour.

For more information on Technical Assistance Services, check the appropriate box on the **HANDSHAKE** reply card. To order Technical Assistance Services or for application assistance, call your local Tektronix Field Office or representative. Technical Assistance Services can also be ordered from the Tektronix National Marketing Center: 1-800-426-2200, ext 7446 (in Oregon call 1-800-627-9000, ext 7446 collect). And be sure to tell them you saw it in **HANDSHAKE.**

Microprobes for tight places



P6501 and P6507 Microprobes are designed to be mounted on the probe card close to the device-under-test.

Two new microprobes from Tektronix feature electronic and mechanical enhancements designed for probing of microelectronic devices. This makes them ideal for testing hybrids, wafers, surface mounted devices, and other high-density circuits.

The P6501 Microprobe is a wide bandwidth, high-input impedance, active probe designed especially for probe-card mounting. Its active FET technology and physical flexibility are optimized for microprobing applications. It features 1 megohm input impedance, capacitance of 1.8 picofarads or less, with bandwidth of 750 MHz. Attenuation through the probe is 10X.

The P6507 Microprobe is a low-profile, 50-ohm passive probe that can be used as an input probe to inject signals into the circuit-under-test. It can also be used as a 50-ohm output probe. Attenuation is 1X and bandwidth is DC to 1 GHz. Space is available on the probe body for adding custom circuitry — for example, a signal blocking or decoupling capacitor.

Designed for high-bandwidth measurements

Based on proprietary Tektronix hybrid circuitry and a proprietary Tek-made integrated circuit, the P6501 ensures clean quantitative measurements, low input capacitance, better linearity, and low aberration levels. This active high-impedance probe makes possible high-bandwidth measurements not possible with low- or uncontrolled-impedance probes. It also eliminates the need for custom-made buffer amplifiers previously required on probe cards to reduce circuit loading.

The P6501 places its electronics as close as possible to the device-under-test to minimize circuit loading and improve signal conditioning.

Keeping a low profile

When analyzing dense circuits, card mounting of probes is necessary for accurate probe placement and repeatability of tests. However, card-mounted probes must operate in confined spaces and share those spaces with other manufacturing and test equipment such as microscopes and lasers. Both the P6501 and P6507 have a low half-inch profile to avoid interference with the objective lenses of microscopes or lasers. Their narrow size also allows high-density placement of many probes on a single probe card (Figure 1).

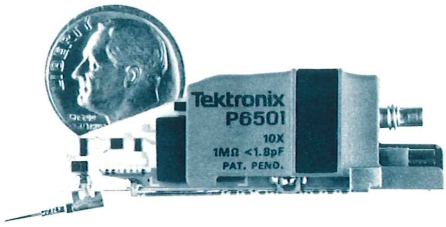


Figure 1. *P6501 probe shown actual size.*

Modular connections

Power and signal cables attach to the probes with removeable connectors eliminating the need to make difficult hand-soldered joints. Modular connections also make the probes more convenient to set up and store between uses. If desired, the probes can be permanently mounted on the probe cards while leaving the power and signal cables connected to the test equipment when probe cards are changed. This can provide significant cost savings for large test setups.

Allowance for a minimum-length ground connection is built into the probe. Or, if desired, ground connection can be made with a separate probe.

Replaceable probe tips

Probe tips are subject to wear, contamination, and breakage. These probes feature replaceable tips to increase their useful life and cost effectiveness, or to update your probe with new tips as they are developed by Tektronix. Two lengths of probe tips are currently — 0.20- and 0.43-inch. A special plug is also available to allow you to design your own custom probe tips.

Interchangeable tips also increase probe versatility. The same probe can be used with, for example, a palladium tip on the soft gold surface of an integrated circuit or a tungsten tip on a ceramic thick-film hybrid circuit.

For more information

For further information on the P6501 or P6507 Microprobe, contact your local Tektronix Field Office or representative. These probes can also be ordered through the Tektronix National Marketing Center — call 1-800-426-2200 toll-free (in Oregon call 627-9000 collect) and tell them you saw it in **HANDSHAKE**. For a data sheet, check the appropriate box on the **HANDSHAKE** reply card.

Customer training classes and workshops

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

CLASS	LOCATION	DATES
Analog Realtime Oscilloscope Workshops		
XYZ's of Using a Scope (based on the 2200 Series)	Call for schedule	
Parametric Measurements and Advanced Parametric Measurements (using the 2445/A and 2465/A Oscilloscope)	Atlanta Detroit Santa Barbara Denver	Mar 18-19 Apr 1-2 Apr 15-16 Apr 29-30
Digital Storage Oscilloscope Workshops		
Basic Digital Storage Fundamentals (using the 2230 Oscilloscope) and Advanced Digital Storage Fundamentals (using the 2430 Oscilloscope)	Boston Seattle	Apr 14-16 May 5-7
Waveform Processing (using the 7854 Oscilloscope)	Chicago Philadelphia Woodbridge Dallas Boston	Mar 31-Apr 1 Apr 21-22 May 6-7 May 19-20 May 20-21
Advanced Waveform Processing (using TEK SPS BASIC, 7612D Digitizer, 7912AD Digitizer)	Beaverton	Apr 21-24

IG Customer Training Workshops

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

Controllers and Other Workshops		
High-Speed Measurements Using Sampling Techniques	Chicago Philadelphia Woodbridge Dallas	Apr 2 Apr 23 May 8 May 21
Using a 4041 Controller for Automation	Chicago Dallas Rochester	Apr 7-9 Apr 28-30 May 12-14
Using the IBM-PC as a Controller	Indianapolis Dallas	Mar 20 May 1

Registration information

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

For more information or to register for these workshops, call Tektronix IG Customer Training, 1-800-225-7802 (in Oregon, call 629-1017), or contact your local Tektronix Field Office.

We retain the option to cancel or reschedule a workshop.

continued on page 36

Hands-on help where the action takes place.

Tektronix Service now comes to you! At Tektronix, we 've closely coupled design and service requirements right at product inception. It's an internal 'Team Tektronix' approach involving engineering, manufacturing and service that's enabling us to provide you with a new level of service responsiveness.

Tek 'new-era' 11000-Series Oscilloscopes are being introduced with complete on-site support. These leading-edge scopes are system-configurable to offer unheard of capability in waveform capture, measurement and display.

On-Site 'Warranty-Plus' support is tailored specifically for the 11000. It includes at least one year of on-site service which can include installation, user orientation, performance testing, calibration, and planned maintenance.

It's all part of our continuing effort to get closer to you and your needs. Tektronix wants to provide you with "Quality service for a Quality product." For more information on Warranty-Plus for the 11000, or for information on Tek services for other products, please call ***1-800-835-6100.*** *From there, we'll connect you with the nearest Tektronix sales and service office—the Tektronix team in your neighborhood.*

Photo: Dale LaFollette

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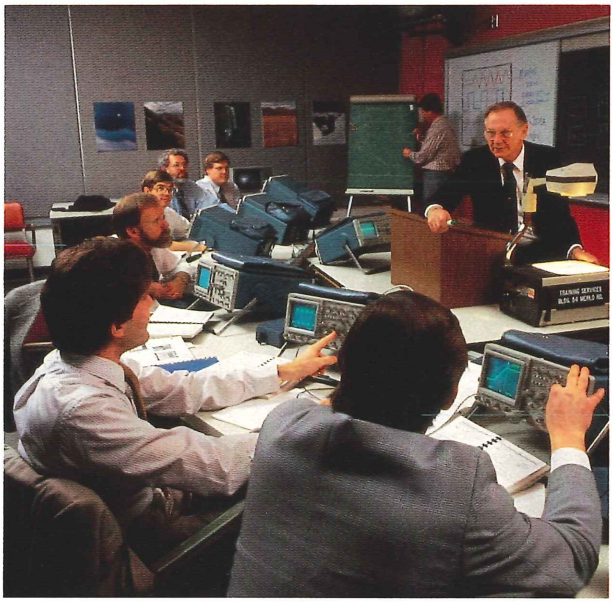

Service Training Classes

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

CLASS	LOCATION	DATES
465B/475A Portable Oscilloscope	Wash. D.C. Chicago	Apr 27-May 1 Jul 27-31
2465/A Portable Oscilloscope	Irvine Atlanta	May 4-15 Jul 20-31
2430 Portable Digital Storage Oscilloscope	Beaverton	Aug 3-14
7612D Programmable Digitizer	Beaverton	May 11-22
7904 Oscilloscope/7633 Storage Oscilloscope	Boston Chicago Irvine	Mar 23-Apr 3 Apr 28-May 8 Aug 10-21
7912AD Programmable Digitizer	Beaverton	Jul 13-24
TM 500 Calibration Package	Chicago	Jul 6-10
TM 5000 Digital Counter/ Digital Multimeter	Beaverton	Call for schedule
TM 5000 Multifunction Interface/Function Generator	Beaverton	Call for schedule
TM 5000 Signal Generator/ Distortion Analyzer	Beaverton	Call for schedule

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

Registration information

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

For more information or to register for these classes, call Tektronix Service Training, 1-800-835-6100 (in Oregon, call 629-1407, or contact your local Tektronix Field Office.

We retain the option to cancel or reschedule a class.

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