

TEKTRONIX
Waveform
Digitizing
Instruments



TEKTRONIX®
committed to
technical excellence

Waveform Digitizing Instruments

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Waveform Analysis

In advancing the technologies of physics, chemistry, and electronics, researchers have learned to use a variety of instruments to solve measurement problems. The acquisition of fast transient events is one problem, common to these fields, that has been extremely difficult to solve. The problem is compounded when, in addition to being observed, an event must be analyzed. Several techniques are used, but most are costly in terms of both time and money; many are limited in accuracy and reliability of results.

This brochure describes a new series of Waveform Digitizing Instrument (WDI) configurations from Tektronix. These configurations have been designed to quickly and economically give users the information they need by capturing and processing both transients and repetitive, short duration events. These configurations can be divided into two categories: viewing configurations, the fastest oscilloscopes available; and software assisted configurations, for complete waveform analyses.

A brief discussion of some other transient recording techniques is also included. The WDI configurations are not intended to displace all of those techniques. For some applications, another approach is adequate; for others, the WDI is the only one that can do the job.

Problem

How to Capture a Fast Transient

Perhaps the most widely used method for transient acquisition is an oscilloscope with a camera that uses Polaroid® film. This is a tedious process at best and, while allowing visual analysis, does little to satisfy researchers' requirements for detailed waveform analysis.

Determining the frequency components of an acquired transient illustrates the value of instruments with software analysis capabilities. This can be accomplished by performing a Fourier transform of the waveform data on the scope photos. However, the photos

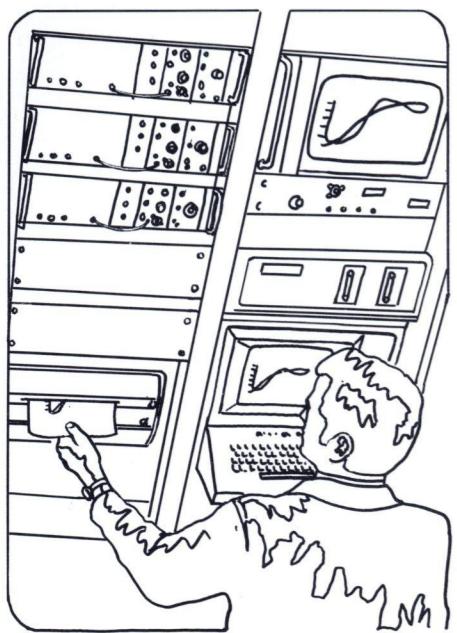
must first be digitized and then the data must be processed. The entire procedure can be complex, time consuming, and vulnerable to human error.

There are, of course, other transient recording techniques. Among them: magnetic tapes, light-beam oscilloscopes, disc recorders, and strip chart recorders. Unfortunately, these techniques do little to overcome the problems of waveform analysis and are limited to low bandwidths.

Another technique uses high-speed analog-to-digital converters. Instrumentation incorporating these A/D schemes are commonly called transient recorders. However, in view of the analysis needs of many researchers, and parameters of super-fast transients, these recorders are severely bandwidth limited. Such instrumentation is virtually useless for detailed study of signal characteristics in the 10-nanosecond to sub-nanosecond range. Also, accuracy is quite limited for many slower signals.

Because of the varying nature of transients, there are uses for each of the above techniques. At one level of equipment complexity, a scope with a camera can be an inexpensive solution to transient acquisition problems when only visual analysis is required. In other applications, such as industrial monitoring and testing, transient recorders may deliver adequate performance. But there are serious problems associated with fast transient acquisition and analysis that are not solved with any of the above techniques.

Pulsed laser research, time-of-flight mass spectrometry, flash photolysis, and EMP studies are good examples. Scopes and cameras can literally bury researchers in un-analyzed data. Days, even weeks, can pass before the results of an experiment are available. As for the other transient recorder techniques, much of this research requires analyses of super-fast single-shot signals that are beyond the ability of traditional A/D recording instruments.



Solution

Acquisition and Analysis Beyond 500 MHz

Because of the need for truly high performance signal acquisition equipment, Tektronix developed the **R7912 Transient Digitizer**. To complete the job of waveform analysis, R7912's (from one to thirty-two) are used as acquisition units in the **WP2000-Series Waveform Digitizing Instrument configurations**. The R7912 Transient Digitizer differs from traditional oscilloscopes in that it is actually a high-resolution scan converter. Yet it retains **mainframe flexibility** by accepting standard oscilloscope plug-in amplifiers and time bases. Input signals are acquired, conditioned, and amplified by vertical plug-ins from the TEKTRONIX 7000-Series family. These provide a wide range of capabilities, from **high gain** (1 mV/div at 100 MHz with the 7A13 Differential Amplifier) to **unexcelled bandwidth** (1 GHz with the 7A21N Direct Access Unit, requires mainframe pc board exchange). The 7B-Series time base plug-ins are used to generate horizontal sweep speeds to 0.5 nanosecond per division.

The R7912 features two modes of operation: **NON STORE**, a television mode for high-speed, low-repetition-rate **signal viewing to 30,000 div/ μ s**; and **DIGITAL**, for **digitizing events to 8,000 div/ μ s**. In terms of analog bandwidth, the R7912 **operates to 500 MHz at 10 mV/div** through a preamplifier plug-in, **or to 1 GHz at \approx 4 V/div** by direct access.

To achieve equivalent performance with traditional A/D converter techniques would require an A/D converter with a variable clock rate of up to \approx 100 GHz, or an effective sampling rate of \approx 10 ps.

The R7912 delivers this performance by digitizing 512 addressable horizontal points with the time base set at 0.5 ns/div (a 5 ns window). There are also 512 addressable vertical points. Because of finite write and read beam widths, the full scale vertical resolution is one part in 320, or \approx 0.25 percent of full scale deflection.

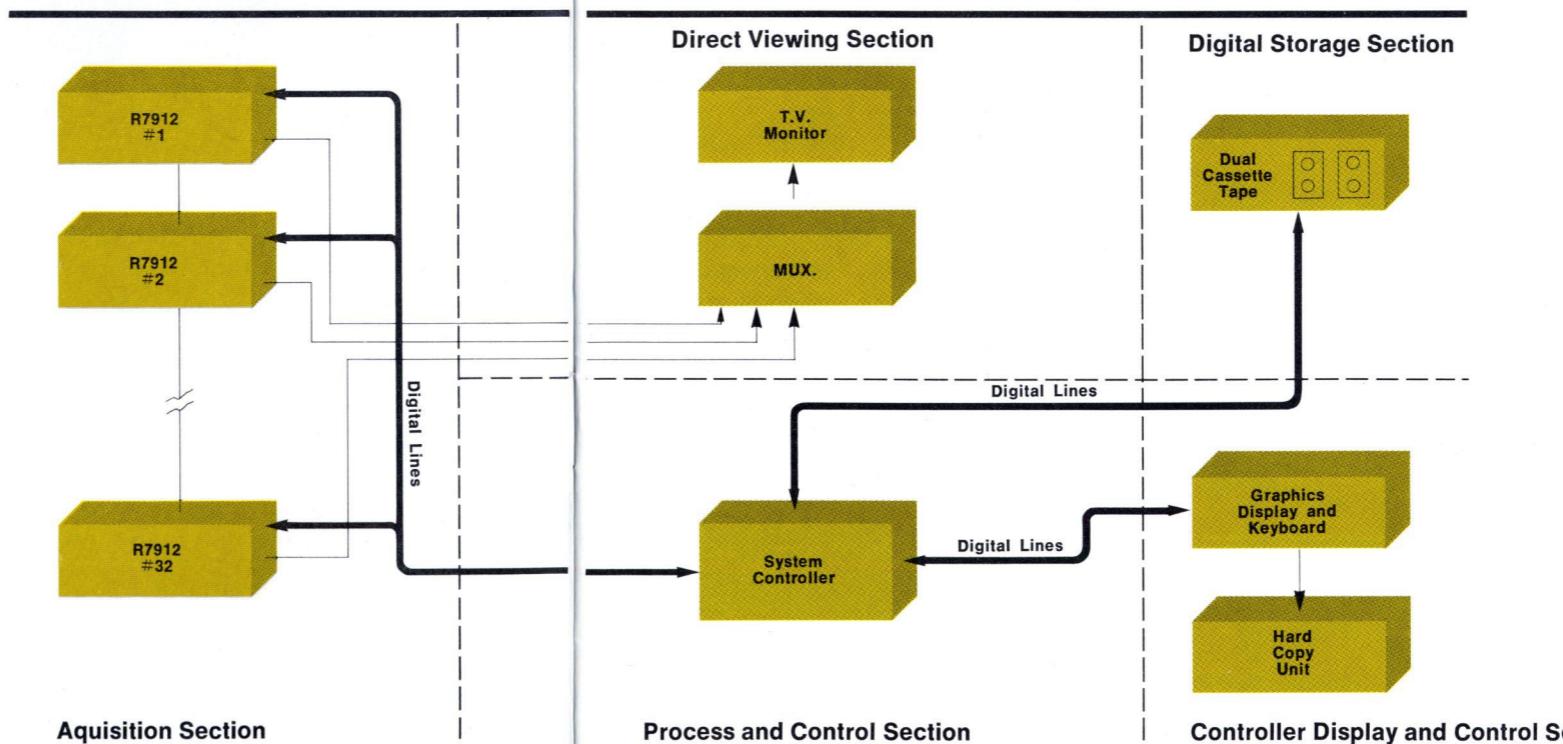
Data that have been acquired and digitized from either non-recurring (single-shot) or recurring signals (including those with low duty cycles) can be stored as a series of 10-bit digital words in a buffer memory. Nine bits are position data; the tenth bit indicates whether the word represents horizontal or vertical position. Once stored, these data are available for digital processing or display.

Scale factor information is available with the waveform data. An electronic dot graticule is also available to provide a reference for waveform measurements on a tv video monitor.

Software Assisted Configurations

For other applications, where it is desirable to acquire the waveform and **immediately perform a full analysis**, there are the WP2000-Series analysis configurations. These include the appropriate number (from one to thirty-two) of R7912 acquisition units, a controller (for waveform processing), a graphics terminal, a tv video monitor, a magnetic tape cassette or paper tape unit, and WDI TEK BASIC software. Also, the Digital Processing Oscilloscope, another Tektronix waveform processor, can be added to WP2000-Series configurations to broaden the acquisition capabilities even further.

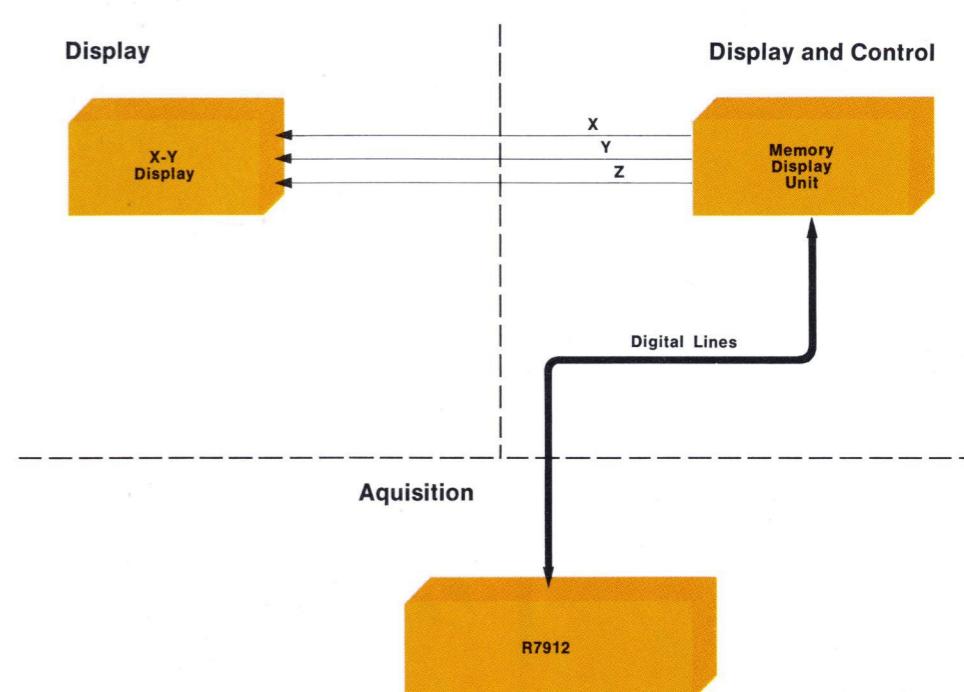
System Block Diagram



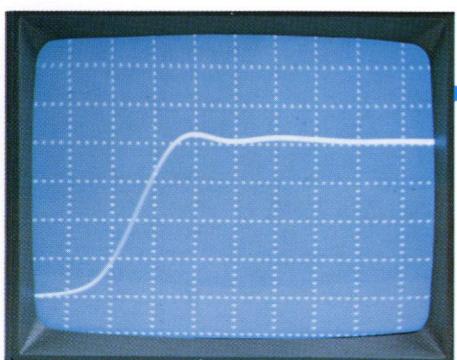
Viewing Configurations

In some applications, it is necessary to monitor several parameters before continuing with an actual experiment. Two good examples from laser research experiments are aligning the laser, and monitoring the sub-nanosecond pulses occurring in the laser train. For these applications, where only visual signal analysis is required, there are the WP2000-Series viewing configurations **—effectively the world's fastest oscilloscopes**. For convenience, a variety of displays is available. Television video monitors can be used for viewing from a distance. Storage monitors and hard copy units can be used to generate permanent copies.

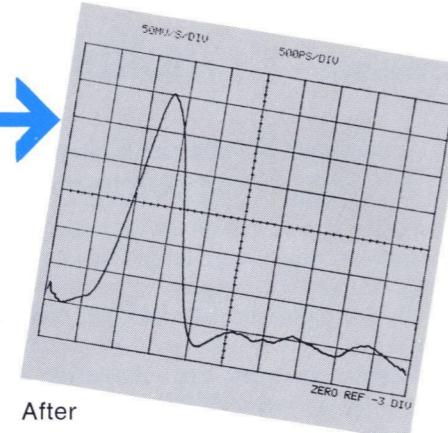
For more detailed information on specific WP2000-Series configurations, and the Digital Processing Oscilloscope, contact the Tektronix Digital Applications Engineer nearest you.



Differentiation

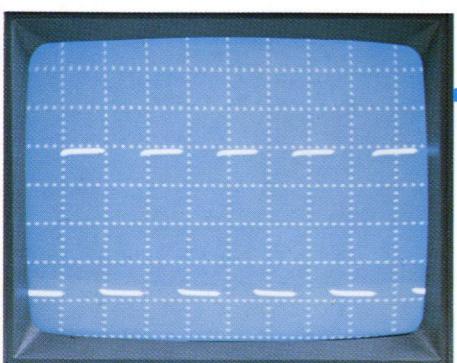


Before

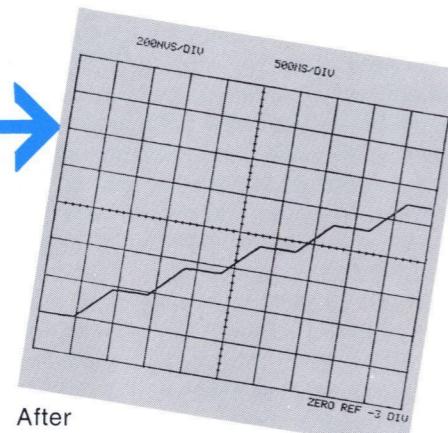


After

Integration

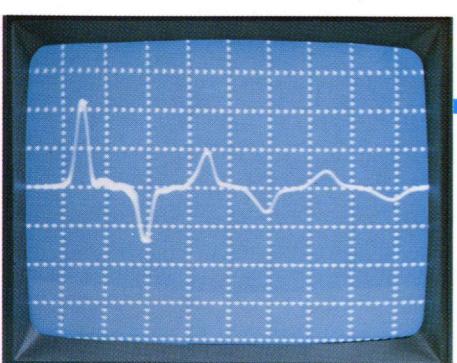


Before

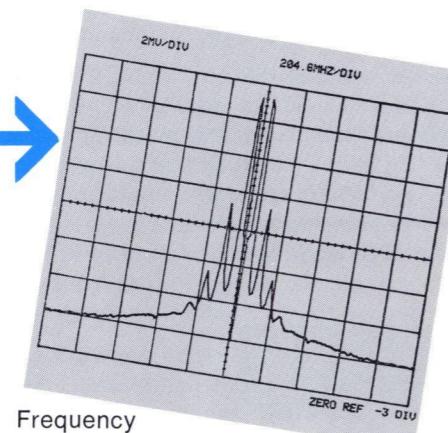


After

Fast Fourier Transform

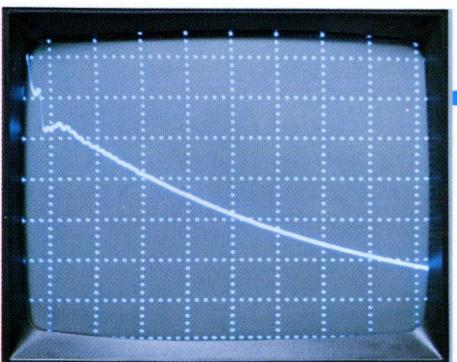


Time Domain

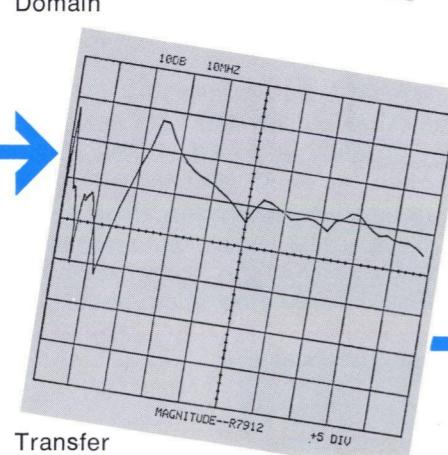


Frequency Domain

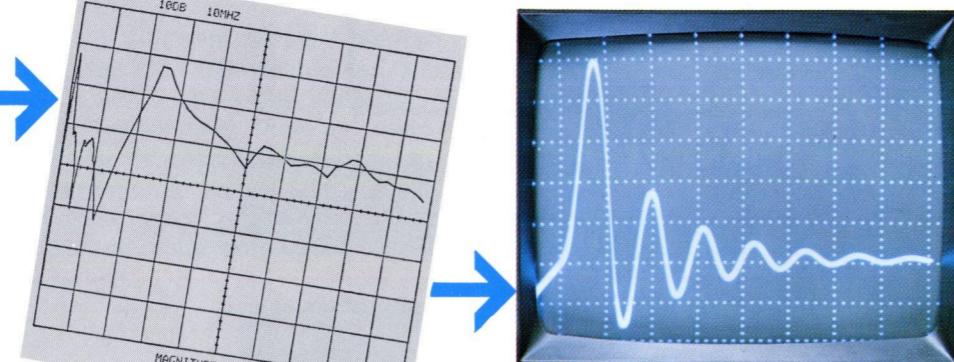
Transfer Functions



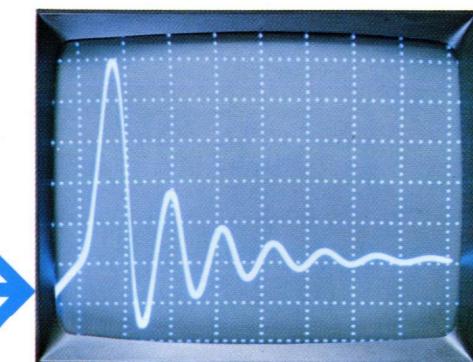
Input



Transfer Function Magnitude



Output



Output

Waveform Processing and WDI TEK BASIC Software

Because detailed signal analyses involve more than simply estimating a few waveform parameters, **software is as important as hardware when considering a measurement system**. You may well be looking for frequency domain data from acquired time domain data. Perhaps you must identify transient pulses by correlating them to known pulses. For these, and a host of other applications, WDI TEK BASIC can help. In many cases, complex waveform analyses can be accomplished with one line statements.

The BASIC Approach

WDI TEK BASIC is an extended version of the BASIC* programming language. It is written in assembly (macro) language for maximum speed of program execution and minimum use of controller memory. Tektronix developed WDI TEK BASIC to facilitate array data manipulations for waveform processing. With it, users can perform analyses of acquired waveforms that are either beyond the scope of BASIC, or are not attainable with standard BASIC programming statements.

Easy to Program

WDI TEK BASIC is **interactive**. Programming via the graphics terminal enables users, even those without formal computer programming experience, to quickly develop measurement and analysis routines. To assist operators, system commands are provided to edit, store, and retrieve programs easily. In addition, **WDI TEK BASIC responds with an error message on the terminal when statements are entered incorrectly**.

*BASIC is an acronym for Beginners All-purpose Symbolic Instruction Code. The language was originally developed at Dartmouth College, and today is widely used in data processing applications in science and industry.

Powerful Through Expanded Capability

Many of the standard BASIC operators, functions, and commands have been retained. With the operators, you can: add, subtract, multiply, divide, and exponentiate. Mathematical functions include: square root, power of e, natural log, absolute value, truncate, random number, sign (+ or -), sine, cosine, and arctangent.

These operators and functions have been extended to **process entire waveforms (512-point arrays) as if they were single-valued variables**. This means that you can write algebraic expressions involving both waveforms and single-valued variables.

Special Functions

Since waveform processing for analysis often requires a knowledge of **mean**, **minimum**, **maximum**, and **rms** values, WDI TEK BASIC contains functions for determining those values, and also contains single-word commands for **integrate (INT)** and **differentiate (DIF)**. These functions save a great deal of programming time. There is also a special function, **cross (CRS)**, that can be used for determining the point at which array values cross a specified level.

Fast Fourier Transform

Analysis of waveforms and transients often includes determining the frequency components of acquired time domain data. This can be accomplished with the fast Fourier transform. The inverse Fourier transform is also provided to reconstruct time domain information from frequency domain data. In WDI TEK BASIC, these are simple commands, **FFT** and **IFT**, that do not require tedious programming. Both can be executed by single-word commands, or incorporated easily into longer user programs.

Transfer Function Analysis

A transfer function mathematically describes the response characteristics of a circuit or a system. By measuring and analyzing both the input and output signals, one can develop the signal transfer characteristics of the circuit or system under test. When cw techniques are inappropriate, transient analysis techniques are required. This is often the case in "real life" environments, and it is in these cases that the WP2000-Series waveform analyzers are most useful.

WDI TEK BASIC allows the user to write his own transfer function algorithms. While the transfer function analysis is a complex measurement to perform, it is probably one of the most useful measurement tools available to the experimenter today.

Software Digital Filtering

When it is required that a signal be filtered, and it is prohibitively expensive, or not practical to build the desired filters from electronic components, digital filtering often provides a solution. The ability of WDI TEK BASIC to simulate desired circuit effects, through operations such as integration, Fourier transform, etc., enables users to synthesize the required filter.

Signals and Noise

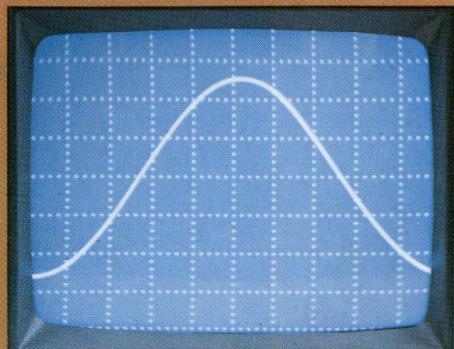
Software techniques useful for viewing signals in the presence of noise include signal averaging and correlation. For repetitive signals, averaging can be used to remove uncorrelated noise. In other applications, such as locating an echo following a stimulus pulse (echo ranging with lidar, radar, and sonar), cross correlation can be used. Auto correlation is also provided, and can be used to detect extremely weak signals accompanied by noise, or to detect the presence of unknown periodic signals interspersed among seemingly nonperiodic signals.

CP1100 Series Controllers

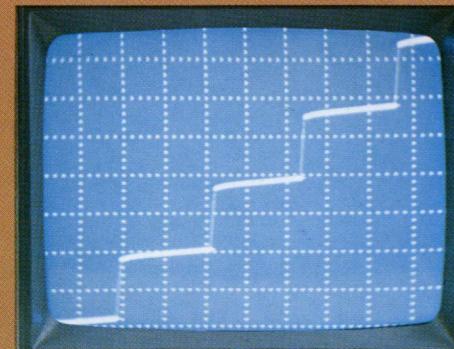
To enable users to take full advantage of the powerful WDI TEK BASIC software, the WDI analysis configurations use TEKTRONIX CP1100-Series controllers. These controllers feature: memory capacities of 16K or 28K, 16-bit words; power fail/restart; automatic priority interrupt, and an asynchronous serial interface to the graphics terminal; and interfaces to the tape cassette or paper tape reader/punch.

Data logging, the ability to store waveforms and programs on magnetic tape cassettes or punched paper tape, greatly enhances the versatility of the equipment. Program libraries may be conveniently stored and retrieved as required. Results of progressive analyses may be stored for future reference or expansion when subsequent data are obtained.

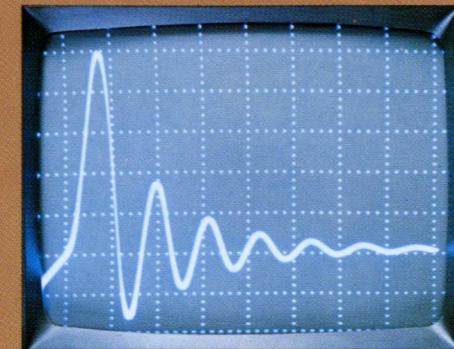
To learn more about WDI TEK BASIC software, circle #1 on the attached card, return it to us, and we'll send you a 32 page WDI TEK BASIC Programming Aid.



For Lasers



For Time of Flight



For EMP

Simulated waveforms

Applications

WDI configurations play a significant role as data acquisition, conversion, and analysis systems in a variety of research and industrial environments. The usefulness of these configurations in diverse environments is enhanced by flexibility of both hardware and software.

In addition to the ability to accept information from purely electronic environments, WDI configurations can process a variety of physical parameter data by using various transducers.

Laser Research

Since the invention of the laser in 1960, the electronics industry has made many instrumentation advances to support laser-related research. The single-shot, five-nanosecond window and digital processing techniques of the WP2000-Series analysis configurations have proven ideal for many laser-generated signals.

In **laser-induced fusion** research, to achieve the desired, efficient burning of thermonuclear fuel, it is necessary to develop lasers that generate extreme amounts of energy in pulses lasting a nanosecond or less. In addition, researchers believe that these laser pulses must be shaped, or "manufactured," to deliver the maximum power (at exactly the right instant) to the deuterium and tritium fuel pellets.

A typical laser apparatus for fusion research may include a YAG oscillator to develop single mode pulse trains, followed by Nd-doped glass amplifiers to raise power levels. The desired high-power output can then be derived by using either disc amplifiers for final amplification, or splitting the beam and using many stages of Nd-doped glass amplifiers.

Several parameters in such a set-up can be monitored with a WDI analysis package. For example, the oscillator pulse purity can be checked by using either fiber optics and a photo diode, or a pellicle at the output of the laser, to obtain pulse information for analysis (via the R7912). Similar techniques can be used to check the purity of pulses at several stages. The power levels of these laser pulses can be measured by integrating each detector output waveform, with the area under the curve representing the pulse power. Other

detectors that provide suitable outputs for the R7912 include Faraday cups, cylindrical analyzers, and secondary electron multipliers.

Other laser applications that require instrumentation with WDI level performance include:

- **Dynamic laser trimming** of active circuits, or devices, by applying power from the laser to do a cutting sequence that will bring the circuit closer to a specified performance level. R7912's can be used to monitor the circuit single-shot response characteristics and thus avoid circuit thermal effects.

- **Laser Interferometry**, a technique that uses the Doppler shift effect of laser beams (an example is to examine an explosion front and detect its motion as well as the size of material within the shock front).

- **Raman Scattering**, a technique that looks at shifts in frequencies scattered or returned from a laser pulse hitting a gas cloud, or target, and re-radiating at a frequency other than the frequency going into the sample.

- **Materials testing in industry**, where lasers are used as a means for strengthening materials (shock hardening steel, aluminum, and titanium alloys by focusing a high-energy laser beam onto the surface of the metal) and for welding by using a high-energy laser beam instead of a flame. Here, R7912's can be used to monitor the lasers (the amount of energy used) and the materials (the effect of that energy on the material).

Time-of-Flight Mass Spectrometry

For time-of-flight (TOF) mass spectrometry, a method of materials analysis whereby atoms can be separated and identified, WDI configurations fit an instrumentation gap. In TOF mass spectrometry, materials are heated to cause emission of ions. These ions are accelerated, focused into an ion beam, and detected in a TOF tube. The mass-to-charge ratio (m/e) of each ion type determines its velocity in the TOF tube.

Ion species identification is accomplished as a function of time, since each species in the sample travels at a different velocity and arrives at the detector at a different time. With the time data, the m/e can be calculated and each species identified.

Electro Magnetic Pulses, EMP

Rapidly changing electromagnetic fields can interfere with or damage a variety of electronic circuits. These EMP signals can be large amplitude pulses, with high frequency oscillations.

Sources of EMP can include lightning arc discharges. Because EMP can damage circuits, vulnerability studies, often requiring a transfer function analysis, must be made, and protection techniques must be developed. The WDI capabilities offer some solutions to the problems encountered in studying the transient nature and high-frequency components of EMP.

Additional Uses

The list of WDI applications is growing, and includes:

Perturbation Kinetics—stopped flow, T-jump, fluorescence decay

Computers—power supply design, bus transient analysis, propagation delay studies

Communications—transfer function analyses

Electronic Warfare—ECM, radar

Component testing—IC parameters, pc boards, filters

Ordnance—shock and acoustic testing

Power supply design—switching transient analysis

Power lines—transient monitoring and analysis

Security systems—transfer function analyses, ciphonics

Navigational systems—pulse code modulation (pcm), timing information

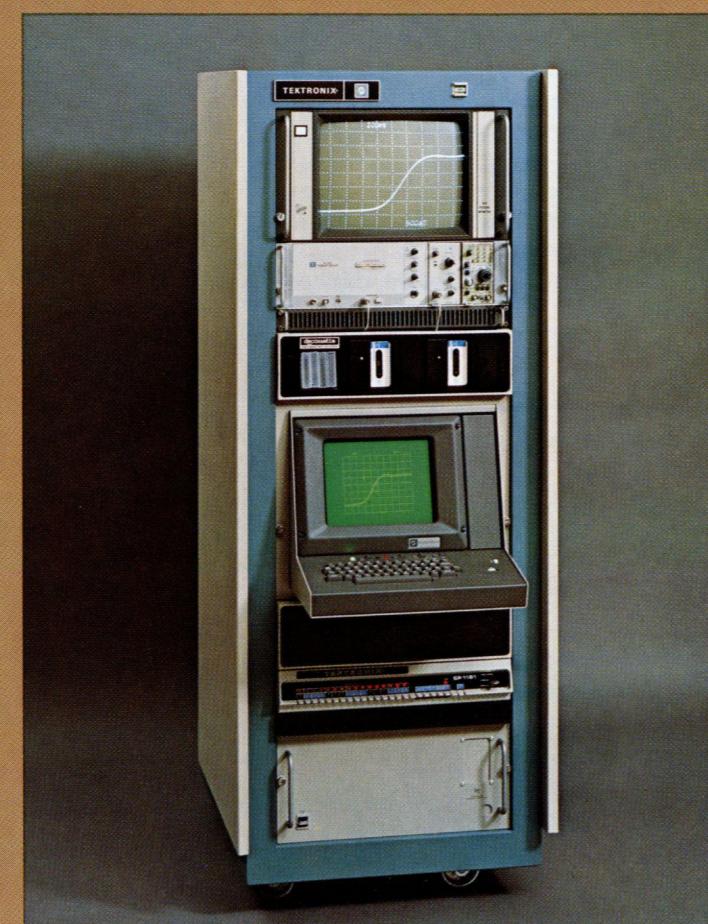
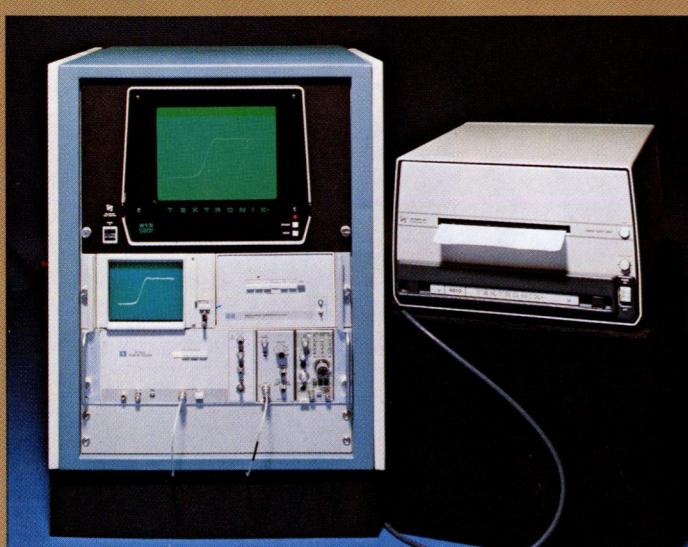
Nuclear magnetic resonance—observing flip resonance

Meteorology—cloud pollution content studies using radar and pulsed lasers

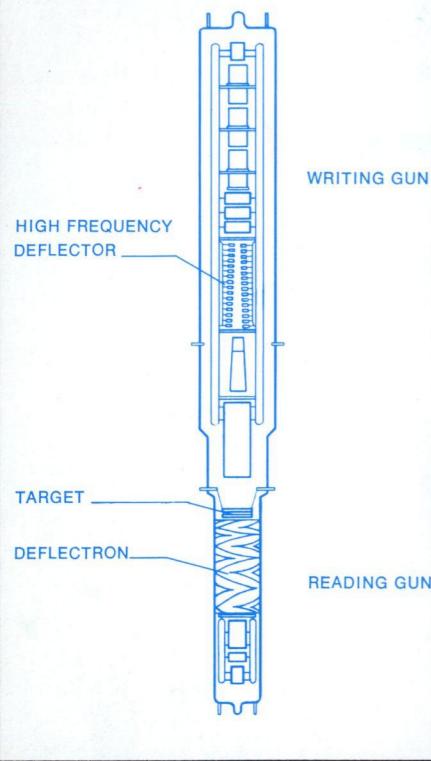
Optics—determining laser-related optical characteristics

Your Tektronix Digital Applications Engineer (DAE) is ready to discuss these applications, and many more, with you.

For copies of WDI Application Notes, circle #2 on the attached card.



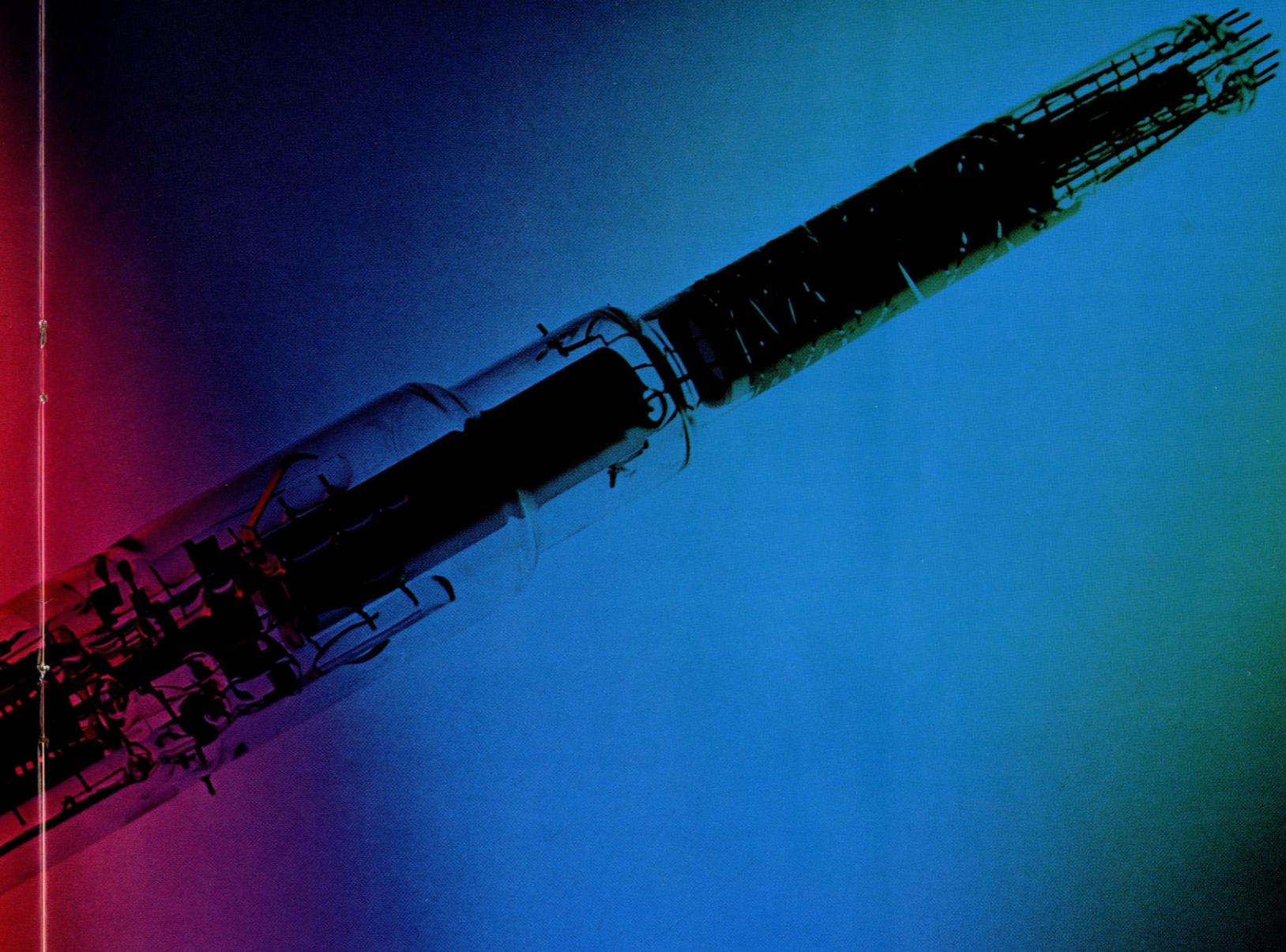
Tube at Work



The outstanding performance of the WDI configurations is due, in large part, to the double-ended scan-converter tube in the R7912 Transient Digitizer. This tube enables WDI configurations to acquire fast single-shot or repetitive signals and convert them to much slower analog (tv) or digital signals.

An input signal is written on the target by the writing gun; it is read out by the reading gun. With the R7912 operating in the NON STORE mode, the reading beam scans the target linearly in a tv format. The operation is similar to that of a conventional tv camera. Each time the reading beam crosses a written point, a small current pulse is generated in the target lead. The pulse is amplified and processed to provide the video output signal.

In the DIGITAL mode, the read sequence is changed. The target is scanned in discrete steps in a 512 by 512 matrix rather than linearly. Vertical scanning is used in the DIGITAL mode to effect optimum waveform definition. The addresses of points on the target are transferred and stored in memory only when a trace has been written at those points on the target.



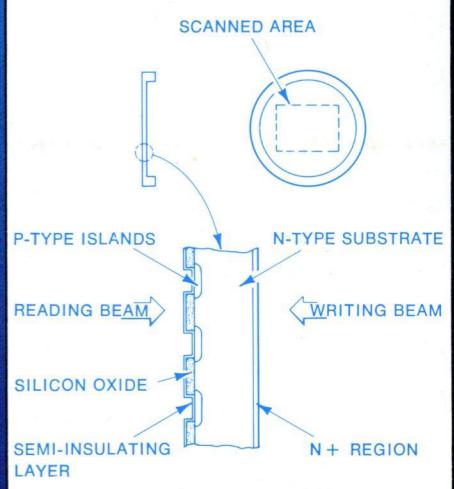
The Target

The write gun electron beam writes and stores information on a diode matrix target that has 262,144 addressable points (512 vertically by 512 horizontally). The target array consists of diode junctions formed on a thinned N-type silicon substrate. Diffused into the back is a thin N+ layer that creates an internal field and repels carriers away from the surface. Over the front is a semi-insulating layer that prevents charging of the oxide web surrounding the diodes.

A density of 2,000 diodes per inch yields the desired resolution for the $\frac{1}{2}$ -by- $\frac{3}{8}$ -inch scanned area. The center 0.75-inch diameter of the target is thinned to about 10 microns. This facilitates the double-ended mode of operation.

For a detailed six-page article describing the operation of the scan converter technique used, circle #3 on the attached card.

Silicon Diode Array Target



The Case for the R7912 Transient Digitizer.

The digital conversion of analog events to suit the requirements of machine data processing techniques can cause errors because of the resolution and time uncertainty in the digitizing process. These errors become increasingly evident as bandwidth requirements are extended. The effect of these errors is to limit the validity of the data, especially in waveform analysis, where the value of calculations to obtain frequency and phase information can be jeopardized.

When scan conversion is not used, the instantaneous amplitude of a continuously varying waveform can be digitally identified only if the digitizing process occurs at the same instant. Hence, the conversion of high speed waveforms requires the use of very high sample rates. If the Nyquist criterion is not observed however, some of the instant-

aneous values will be lost, and interpolation will leave doubt as to the values between the digitized steps. Also, time uncertainty, sometimes called "aperture error", and signal slew rate will contribute to amplitude inaccuracy. This type of error is substantially reduced in the R7912 because it is the stored "image" of the event that is digitized, rather than the event itself as it occurs.

Tailored Performance

A comprehensive range of TEKTRONIX 7000-Series Plug-in Amplifiers provides R7912 input characteristics to suit most applications. Many bandwidth, sensitivity, and input impedance combinations provide versatility.

Vertical Amplifiers. Plug-in amplifiers such as the 7A16A, 7A19, 7A21N, and 7A24 may be used in the left-hand compartment of the R7912.

• **7A16A**—provides bandwidth from dc to 225 MHz, amplitude range of 5 mV/div to 5 V/div with $1\text{ M}\Omega$ input impedance.

• **7A19**—provides bandwidth to 500 MHz, amplitude range of 10 mV/div to 1 V/div with 50-ohm input impedance.

• **7A21N**—provides bandwidth to 1 GHz with direct access (requires pc board exchange in the R7912 mainframe) <4 V/div amplitude range, 50-ohm input impedance.

• **7A24**—provides dual-channel capabilities with bandwidth from dc to 350 MHz; allows for adding timing markers. 5 mV to 1 V/div with 50-ohm input impedance.

Time Base Units. Plug-in time bases such as the 7B70 and 7B92 may be used in the right-hand compartment of the R7912.

• **7B70**—provides calibrated sweep speeds to 2 ns/div, trigger frequency to 200 MHz.

• **7B92**—provides calibrated sweep speeds to 500 ps/div, delaying sweep for repetitive or single-shot events, trigger frequency to 500 MHz.

Brief Comparison of Digital Conversion Techniques

Parameter	Scan Conversion	Parallel A/D	Sample and Hold A/D
Analog Bandwidth	500 MHz to 1 GHz	25 MHz	25 kHz to 10 MHz
Analog Rise Time	700 ps to 250 ps	12 ns	17.5 μ s to 35 ns
Nyquist Bandwidth	50 GHz	50 MHz	50 kHz to 20 MHz
2 points per risetime	20 ps	20 ns	20 μ s to 2 μ s
Accuracy	to 1%	Signal dependent	to 1 %
Record length	512 points	2,000 points	4,000 points
Record time			
Single shot	5 ns to 100 μ s	20 μ s to 5 hrs	200 μ s to 5 hrs
Repetitive	5 ns to 100 ms	20 μ s to 5 hrs	200 μ s to 5 hrs

Performance Characteristics

For Acquisition

The R7912 Scan Converter CRT—Double-ended, dual-gun type.

Resolution of digital data, stored in the R7912 on a 512-point by 512-point matrix, is rated, best case, at 1 part in 320 for vertical values and 1 part in 400 for horizontal values.

Distortion because of beam velocity modulation can occur but, in the worst case, the amplitude of any instrument generated harmonics will be more than 30 db down from the fundamental for a sinusoid of 20 cycles at 90 percent of full screen amplitude. Transients with an amplitude of 90 percent of full screen and a beam intensity/velocity ratio of up to 10:1 can be digitized. In either case,

the results are repeatable; therefore, software enhancement techniques can be used to advantage.

Writing Rate—NON STORE mode: visual writing rate—30,000 div/ μ s (when viewed on a TEKTRONIX 632 Picture Monitor). DIGITAL mode: digital storage writing rate—8,000 div/ μ s.

Memory:

TYPE—Static semiconductor memory, non-destructive readout.

SIZE—4096 words by 10 bits.

CYCLE TIME—1.6 μ s per word or slower.

OUTPUT—Bit parallel; word serial; 9 data bits plus 10th-bit flag.

Vertical System:

CHANNELS—Left-hand plug-in compartment—compatible with 7000-Series plug-ins. Bandwidth determined by plug-in unit.

CHOPPED MODE—Chop rate determined by vertical plug-in selected.

DELAY LINE—Permits viewing leading edge of displayed waveform.

Horizontal System:

CHANNELS—Right-hand plug-in compartment—compatible with time bases of the 7B70 and 7B90 Series.

CALIBRATED SWEEP SPEED—to 500 ps/div with 7B92.

For Viewing

The **WDI viewing configurations** can be used as either ultra-fast oscilloscopes or storage media for brief events. Bright, clearly visible displays of the events are provided in "realistic" time. Depending on the configuration, events can be recorded as hard copies or by other photographic methods. Some features are:

Large Bright TV Displays, VTR data logging possible.

High Writing Rates, DIGITAL mode 8,000 div/ μ s, NON STORE (tv) mode 30,000 div/ μ s

CRT Storage Capability, provides optimum performance at lowest cost

Digital Storage Capability, provides memory refreshed displays with non-storage monitors

Hard Copies in Seconds from a Tektronix hard copy unit and a 613 Storage Display Unit

For Software Assisted Analysis

With **WDI software assisted configurations**, complete measurement and analytical procedures can be performed. Enhancement and editing software routines are also provided to aid in the task. For future use and reference, program libraries can be generated for particular classes of events. Capabilities include:

Software Waveform Analyses

- FFT
- IFT
- Convolution
- Correlation
- Differentiation
- Integration
- Maximum
- Minimum
- RMS
- Cross
- Addition
- Subtraction
- Multiplication
- Division

Software Control

- DIGITAL mode
- NON STORE (tv) mode
- Graticule
- Scale factor information
- Signal channel selection
- Sweep arming
- Memory lock

Dual Digital Cassette

- Program storage
- Waveform storage (data logging)
- Very convenient operation

Paper Tape Reader Punch (optional)

Graphics Display Terminal

- Large, easy to view display
- Graphic display capability

- Keyboard for system control and program writing
- 8½" by 11" hard copies in seconds from a Tektronix hard copy unit

TV Monitor

For signal viewing and acquisition unit set up

Multi Channel Capability

Up to 32 acquisition units can be incorporated in one configuration

Controllers

- CP1151 with 28k of core memory (16k optional), 16-bit words, and a cycle time of 2.7 μ s
- CP1160 with 28k of core memory, 16-bit words, and a cycle time of 0.9 μ s



Business Information

It is the intent of Tektronix, Inc. to consistently provide unexcelled product service and support at competitive prices. To ensure reaching this goal, Tektronix subsidiaries, distributors, and service centers have been established at strategic locations in countries all over the world.

Some services, configurations, and instrument options are not available outside the United States. The Tektronix subsidiaries or distributors will be glad to furnish details.

In the United States Digital Applications Engineers

Tektronix maintains a field sales force of highly trained Digital Applications Engineers. These DAE's possess strong technical backgrounds and have extensive product and business training. Because of this, DAE's are competent to help you select the WP2000-Series Waveform Digitizing Instrument configuration best suited to your measurement needs, both present and future.

Data System Specialists

Warranty and maintenance support in the U.S. for products from the Measurement Systems Division of Tektronix is provided by a competent staff of Data System Specialists. Through continuous contact with the factory, these specialists can maintain your system to assure its best performance, and, when needed, provide warranty service.

Customer Applications Engineers

At Tektronix, product support goes beyond the sale and warranty of our products. For custom applications, where special software and technical assistance is required, Tektronix Customer Applications Engineers are available to help you.

Customer Training

To assist you in achieving the highest level of performance from the WDI configurations in the shortest possible time, Tektronix provides both hardware and software training classes. Your nearest DAE can give you details on class schedules, duration, and location.

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WP-Series Product Warranty

Tektronix WP-Series products are warranted against defective materials and workmanship for a period of one (1) calendar year. Tektronix will repair products failing to meet specifications during the warranty period at no cost to the customer.

When practical, repairs are made in a Tektronix Service Center where test and repair equipment is maintained. For information regarding on-site warranty service, contact your Tektronix Digital Applications Engineer.

In addition, during the warranty period, Tektronix provides two (2) verifications of calibration of the WP-Series products.

Where Tektronix WP-Series products are used in conjunction with equipment or systems not supplied by Tektronix, on-site warranty service is not provided.

Post-warranty service is provided at prevailing rates or by service contract.

Ordering

Your Digital Applications Engineer will provide you with information on prices, terms of sale or lease, and best method of transportation for all WDI configurations and accessories.

A complete list of Tektronix Field Offices with resident DAE's is listed on an insert to this brochure. If the insert is missing, call (503) 644-0161 ext 6008, or write to: Tektronix, Inc., Measurement Systems Division, P.O. Box 500, Beaverton, OR 97077, for the name and number of the DAE in your area.

For Customers Outside the United States

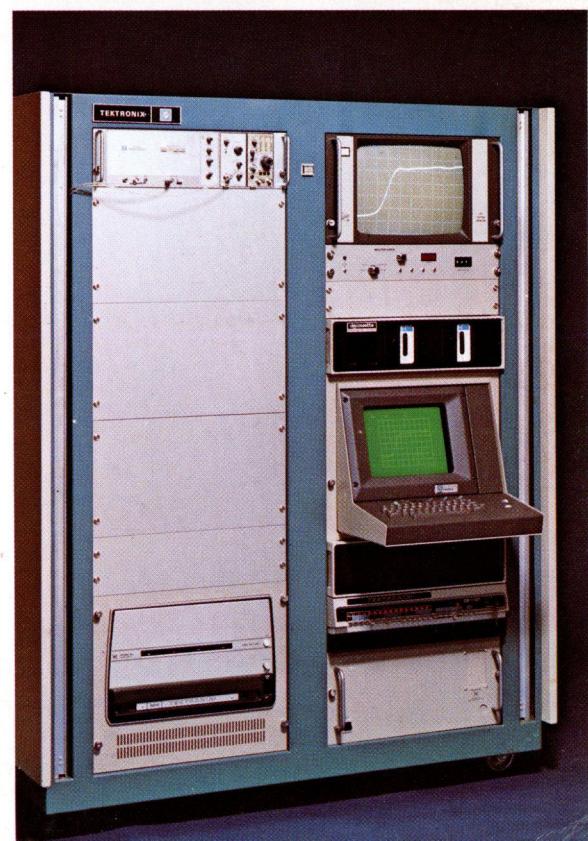
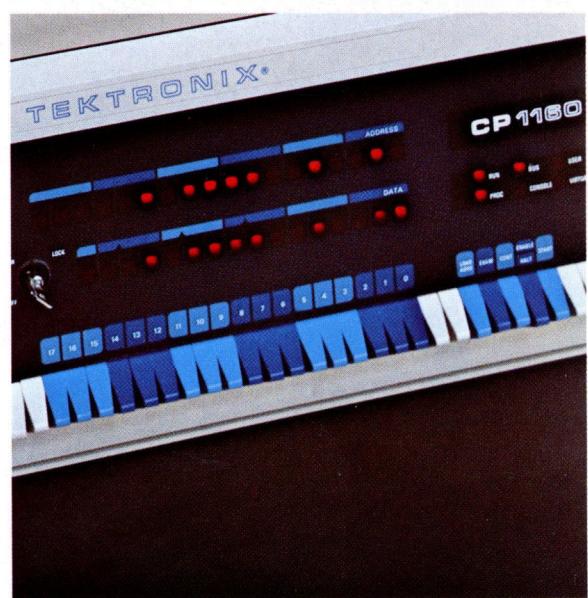
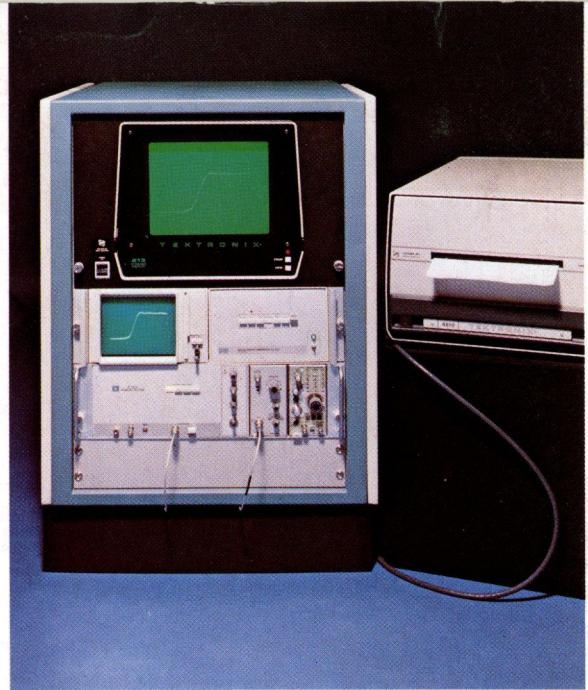
To provide you with personal assistance in ordering as well as servicing products, Tektronix has established subsidiaries and technically qualified distributors in many countries throughout the world. The Tektronix subsidiary or distributor in your country will be pleased to help you select among the WDI configurations, related products, or other Tektronix products that best suit your requirements in performance.

In countries without a Tektronix subsidiary or distributor, please address your inquiries to:

Tektronix, Inc.
International Sales Office
P.O. Box 500
Beaverton, Oregon 97077 U.S.A.




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