7000 Series Instrumentation To Complement AN/USM-281C

...more than an oscilloscope
WP1100-SERIES
DIGITAL PROCESSING
OSCILLOSCOPES

The WP1100-Series DPO is a calculator
aided instrumentation system that offers the
computational capabilities to solve a variety
of data acquisition and analysis problems.
With this system, the full signal acquisition
capabilities of the TEKTRONIX 7000-Series
laboratory oscilloscope have been main-
tained and have been reinforced with the
data processing capabilities of the TEK-
TRONIX 31 Programmable Calculator.

A key feature of the WP1100-Series is that it
enables operations with waveforms to be
performed under program control. Wave-
forms digitized by the DPO are acted upon
by programs stored in the calculator.

A stored waveform can be operated on by
another waveform; the two can be multiplied,
subtracted, etc., to obtain a third waveform.
It is also possible to perform operations (cal-
culate integrals, differentials, etc.) on a
single waveform to obtain a second. Re-
sultant waveforms are displayed with ap-
propriate scale factors.

The WP1100 also allows alphanumeric mes-
sages to be sent from the calculator to the
DPO.

The TEKTRONIX 31 features over 30 built-in
math functions. There are 24 keys that can
be defined to perform special, frequently
used functions. In the WP1100 DPO there
are 256 memory registers and 2048 program
steps. The WP1101 DPO contains 256 mem-
ory registers and 8192 program steps. There
is also a special memory partition switch
that increases the number of memory regi-
sters by decreasing the number of program
steps. The switch gives a choice of memory
and program step allocations as follows: 256/8192, 640/5128, or 2048/1000.

To provide useful and powerful software that
simplifies waveform processing, Tektronix
has developed the KEYBOARD INTER-
PRETER Program, and a Program Keyboard
Overlay to match, for the WP1101. It con-
tains programs to add, subtract, multiply,
divide, log X, integrate, differentiate, X',
signal average, and determine rms, min,
max, and mean values of stored waveforms.

The Keyboard Overlay also has six keys
reserved for user-definable functions. With
those keys, custom programs and subroutines
may be called.

After loading a program, and placing the
overlay in place, waveform computations
may be easily performed. The KEYBOARD
INTERPRETER program will automatically
scale waveforms, process scale factors from
the plug-ins, and process waveform arrays
just as the calculator normally processes a
single variable.

One of the unique advantages of the
WP1100-Series DPO is the value that each
sub-unit has when used independently. Even
without the calculator to process data, the
DPO retains the full acquisition capabil-
ities of a laboratory scope. Indeed, there are
applications where the DPO is significantly
more versatile than the general-purpose scope
from which it was built. Go/no-go testing is a good example. Once calculator
determined waveform parameters are stored
in the P7001 Processor, an operator can
visually compare those with the output of a
device under test. While the DPO is used for
go/no-go testing, the TEKTRONIX 31 Cal-
culator can be disconnected and used else-
where as a stand-alone programmable cal-
culator for any number of applications, from
circuit design to cost accounting. Software
support for stand-alone operation includes
mathematical, statistical, and electronic en-
gineering packages.

For graphic and alphanumeric representa-
tions of measurements and computations, the TEKTRONIX 4661 Digital Plotter is plug-
in compatible with the WP1100-Series. With
the 4661, full or half scale graphs may be
drawn on paper up to 11 x 17 inches. The
full scale mode provides 10 inches of y data
and 15 inches of x data. In the half scale
mode, the plotter accepts 20 inches of y data
and 30 inches of x data.

WP1200-SERIES
DIGITAL PROCESSING
OSCILLOSCOPES

The WP1200-Series DPO, with i/o options,
memory options, and a variety of labor-
saving peripherals, represents a comprehen-
sive, powerful, and flexible data acquisition
and analysis system. This system may be
used for many applications in such fields as
physics, optics, chemistry, mechanics, bi-
ology, and electronics.

Superior performance has been achieved by
incorporating DPO TEK BASIC software,
CP1100-Series controllers, graphic termi-
nals, cassette or paper tape input/output
units, and an optional hard copy unit
into standard DPO configurations. These
WP1200-Series DPO configurations deliver
unmatched performance while the options
ensure flexibility to meet individual require-
ments.

Because of its simplicity and power, the
BASIC software language, developed at
Dartmouth, is now widely used in business,
industry, and science. It is easy to learn and
can be applied to most problems quickly and
easily. An outstanding feature of BASIC is
that it interacts with the user at the terminal
in a conversational way. This gives users
direct control.

To support the DPO, Tektronix has devel-
oped DPO TEK BASIC as an extension of
the Dartmouth BASIC software. Many of the
original BASIC commands that have been
retained have been expanded. New com-
mands have been added to speed waveform
processing and to provide interaction be-
 tween all DPO configuration components
and the user.

Important features of the TEKTRONIX
GP1100-Series Controllers used in Digital
Processing Oscilloscopes include: memory
capacity of 16k, 24k, or 28k of byte-address-
able 16-bit words; power fail/restore; auto-
matic priority interrupt, an asynchronous
serial interface to the graphics terminal; and
parallel synchronous interfaces to the P7001
Processor and the paper tape reader/punch
or tape cassette. These CP1100 character-
istics enable the user to take full advantage
of the powerful software features of both
DPO TEK BASIC and the optional WDI TEK
BASIC software packages.

To assist in writing and editing programs
quickly and easily, the WP1200-Series DPO's
use TEKTRONIX graphic terminals. In addi-
tion to convenient program writing and edit-
ing, the terminals allow viewing analyzed
data quickly, in a variety of tabular and
graphic formats.

For permanent hard copies of graphic termi-
nal displays, the optional TEKTRONIX 4610
Hard Copy Unit may be used. In just sec-
onds, graphs of waveforms, data, and pro-
gram listings are available. These copies, in
an 8 x 10 inch dry copy format, are ideal for
records and reports, and are suitable for
reproduction.

Both paper tape and cassette DPO config-
urations are available. In addition to pro-
viding fast and easy program loading, entire
waveforms can be stored for records or
transferred to another computer.

For more information on Digital Processing
Oscilloscopes, contact your nearest Tek-
tronix Digital Applications Engineer or write
to Tektronix, Inc., P.O. Box 500A, Beaver-
ton, OR 97077.
Waveform Digitizing Instruments (WDI) using the R7912 Transient Digitizer

Transient Analysis and Digital Storage at 8,000 div/µs

Analog Bandwidth:
1 GHz at 4 V/div (direct access)
500 MHz at 10 mV/div

Writing Rate
8,000 div/µs DIGITAL mode
30,000 div/µs NON-STORE (tv) mode

Sampling Rate (Effective):
10 psec (100 GHz) or slower

In advancing the technologies of physics, chemistry, and electronics, researchers have learned to use a variety of instruments to solve measurement problems associated with acquiring fast transient events. The problems are compounded when, the events must not only be acquired, but must also be analyzed.

The Waveform Digitizing Instrument (WDI) configurations have been designed to give users the information they need quickly and economically 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.

For Viewing
The WDI viewing configurations (WP2001, WP2002, WP2003, and WP2004) may be used either as ultrafast oscilloscopes or as storage media for brief events. Bright, clearly visible displays of the events are shown in realistic time. Depending on the configura-
tion, events may 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/μs, NONSTORE (tv) mode 30,000 div/μs
- **Crt Storage Capability** provides optimum performance at lowest cost
- **Digital Storage Capability** provides memory refreshed displays with nonstorage 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, (WP2221, WP2222, WP2321, WP2322), complete measurement and analytical procedures may be performed. The enhancement and editing routines of the software, WDI TEK BASIC, also aid in the task. For future use, program libraries may 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
- NONSTORE (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
- 8¼ x 11-in hard copies in seconds (from a TEKTRONIX hard copy unit)

**Tv Monitor**

For signal viewing and acquisition unit setup

**Multichannel Capability**

Up to 32 acquisition units may be incorporated in one configuration

**Controllers**

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

**The case for the R7912 Transient Digitizer.**

Converting analog events to digital information and meeting 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. These errors limit the validity of the data, especially in waveform analysis where the results of frequency and phase calculations may be affected.

When scan conversion is not used, the instantaneous amplitude of a continuously varying waveform may 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 instantaneous values will be lost, and interpolation will leave doubt about 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 rather than the event itself that is digitized.

**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.

**Time Bases Units.** Plug-in time bases such as the 7B70 and 7B92A may be used in the right-hand compartment of the R7912.

**R7912 Performance Characteristics**

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 may 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% of full screen and a beam intensity/velocity ratio of up to 10:1 may be digitized. In either case, the results are repeatable; therefore, software enhancement techniques may be used to advantage.

Writing Rate — NONSTORE mode: visual writing rate —30,000 div/μs (when viewed on a TEKTRONIX 632 Picture Monitor). DIGITAL mode: digital storage writing rate—8,000 div/μs (equivalent to a digitizing rate of 100 points/ms).

**Memory:**

- **Type** — Static semiconductor memory, nondestructive readout.
- **Size** — 4096 words by 10 bits.
- **Cycle Time** — 1.6 μs 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 7B92A.