VOL 14 NO 3, FALL 1989

TEK HANDSHAKE™

YOUR VISIBLE EDGE IN MEASUREMENTS

BREAKING LOGIC ANALYSIS BARRIERS

FEATURED INSIDE:

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- A new standard of performance ...
- VXI — foundation for the future ...
- 3-D analysis ...
- Taking the plunge ...
- The Analytek Series 2000 ...
- New Product Update

Test and Measurement ... Tektronix is committed to the test and measurement needs of its customers. We express this commitment by not only the design and manufacture of innovative products, but also by support after the sale.

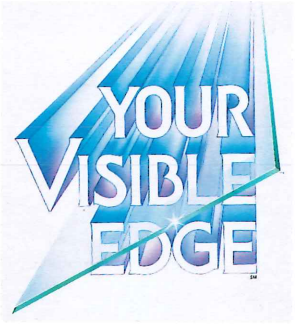
To enhance our response to the needs of our test and measurement customers, Tektronix has formed the Test and Measurement Group. This action brings together, under one common umbrella, the traditional oscilloscope, digitizer, spectrum analyzer, logic analyzer, and measurement system activities.

For you, our customers, this means a closer link between the sales and service of the various Tektronix Test and Measurement products. It also means a total solution for your measurements needs. For us at Tektronix, this means an opportunity to closely integrate our design, manufacturing, and support activities across the total Test and Measurement line.

In the last issue of **HANDSHAKE**, we introduced Tektronix as ***Your Visible Edge*** in Measurements. We invite you to take a closer look at any of our test and measurement products to see why they have the visible difference — a visible difference in design, manufacture, and measurement capability. Just call one of our sales offices anywhere around the world and tell them you'd like to see the visible difference that a Tek instrument can make in your measurements. We're sure you'll see the difference the Tektronix commitment makes!

Tektronix — *Your Visible Edge* in Measurements!

Richard I. Knight
Vice President, Test and Measurement Group
Tektronix, Inc.



Formula correction

In the article **Establishing the basis for differential TDR measurements with the 11800-Series Oscilloscopes** printed in the Spring 1989 **HANDSHAKE**, we used the wrong formula for measuring differential impedance directly. It should have been:

$$Z_d = 100 * (1 + M1 - M2) / (M1 + M2)$$

We hope this didn't cause any difficulty for any of our readers. Our thanks to Gilbert Gnudi from Tek Germany for calling this to our attention.

For information or prices on products described in this issue, call the Tektronix National Marketing Center 1-800-426-2200

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A look inside

In this issue, we bring you some more insight into the new measurement tools available from Tektronix. We start with the article **Breaking logic analysis barriers** which describes how the Prism 3000 Series can remove the barriers encountered in system integration by coordinating all of the logic analysis tools within one package.

In the article **A new standard of performance... The 2782 Microwave Spectrum Analyzer** you'll find how the 2782 has extended or improved performance for every major aspect of spectrum analysis — and in a portable instrument too! Another spectrum analyzer, the 3052 Digital Spectrum Analyzer, is described in the article **3-D analysis of interleaved harmonic signals.** This shows one of the many difficult or previously impossible measurements that are easily made with this unique instrument.

VXI has recently become an important topic in technical circles. Tektronix is part of the VXI revolution. To find out more about VXI and Tektronix VXI products, read **VXI — foundation for the future.**

If you're trying to make that difficult choice between an analog and a digital scope, you need to read the article **Taking the plunge into DSOs.** It provides some basic questions and considerations to help you feel confident with your choice — whether you make the move to digital or stay with analog technology. This article is a good companion to the **Choosing test equipment to match your application** and **Evaluating scopes from A to D...** articles in the Summer 1989 **HANDSHAKE.**

A new instrument for digitizer measurements is described in **The Analytek Series 2000 Waveform Sampler.** This new modular digitizer allows you to tailor the number of channels and digitizer performance to your application.

The **New Product Update** introduces some new instruments, software, and accessories to expand ***Your Visible Edge*** in measurements. Please contact your local Tektronix Field Office or sales representative for assistance with any of your measurement needs. And tell them **HANDSHAKE** sent you!

A. Dale Aufrecht
HANDSHAKE Editor

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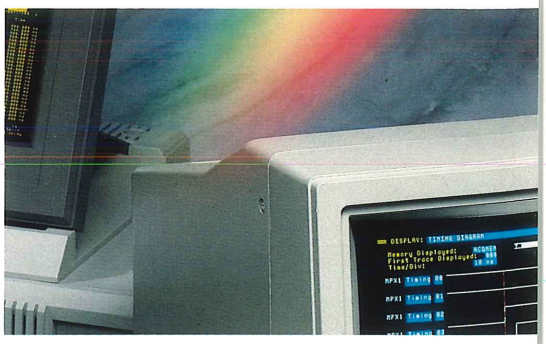
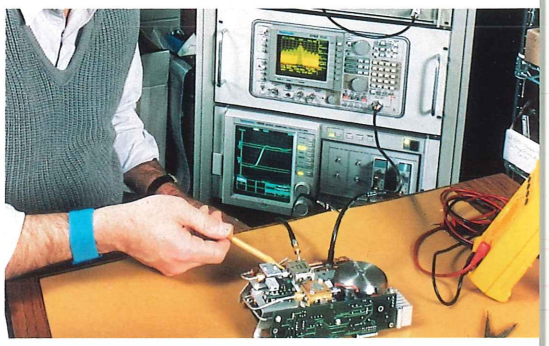




Breaking logic analysis barriers

The Prism 3000 Series offers a variety of platforms and card-modular options for complete, tightly integrated logic analysis and microprocessor control. This provides integrated solutions for hardware, software, and system verification, debug, and performance analysis — all from a single, medium-cost logic analysis platform.

Digital designers are taking full advantage of ASICs, microprocessors, and a wide range of powerful CAE tools. Digital processing and control designs far too complex to even be attempted a few years ago are now considered standard fare. But, while design barriers continue to fall, other new barriers are cropping up in the design implementation and prototype stages.

These new barriers are logic analysis barriers. They are barriers created by complex system integration problems. Some are hardware related; some are software related; still others are hardware/software integration related. In almost every instance, however, the barriers actually center on difficulties in coordinating logic analysis tools and correlating results. Or at least that was the case.

Now, with the Tektronix Prism 3000 Series, you have the power to solve virtually any logic analysis problem, be it hardware, software, hardware/software, or multi-processor related. The Prism 3000 Series provides the key tools — state and timing analysis, microprocessor control and analysis, and performance analysis — all tightly integrated into a single high-performance, mid-priced package.

The power of tight integration

Much of the Prism 3000 Series analysis power stems from its tightly integrated, card-modular architecture (Figure 1). Multiple analysis and control tools are combined into a single instrument with a single operating environment and a single, unified display of correlated results. This immediately solves numerous logic analysis barriers encountered when using individual standalone analyzers and emulators. Probing is simplified. Multiple analysis displays are combined on one screen for easier viewing and interpretation. And there's only one instrument operating interface to deal with.

But that's only the beginning. With inter-module event lines, many complex triggering problems are also easily solved. For example, when using a separate logic analyzer, a scope, and an emulator, how would you go about getting all three to trigger on a fault? Chances are, you probably would never get satisfactory cross triggering between three separate instruments. And even if you did, you'd have to wonder about timing skews across the different instruments.

But with these same tools in a single tightly integrated package, cross-triggering is easy. For example, using a standard triggering setup, the state analyzer section can be triggered on a subroutine that's taking too long to execute. This in turn could trigger the timing analyzer section, or the PDT (Prototype Debug Tool) could be triggered to stop microprocessor execution. State, timing, and disassembly displays can be viewed in any combination to gain further insight into the problem. Then, depending on what's revealed, the PDT can be used to examine registers, patch code, single-step execution of code, or whatever else is necessary to define and fix the problem (Figure 2). Once a fix is developed, the performance analysis section can be applied to verify how good that particular fix is.

Time-correlated displays

The ability to cross-trigger various tools and view various mixes of acquired data on a single display is not enough. The displays must also be time correlated in order for various data relationships to be correctly interpreted.

To accomplish time correlation, the Prism 3000 Series samples, latches, and time stamps all data at the probes. In essence the analysis tool's front end — whether it's state, timing, or multiple-threshold waveform acquisition — has been moved down into the probe.

This, along with a single system clock, maintains proper timing across

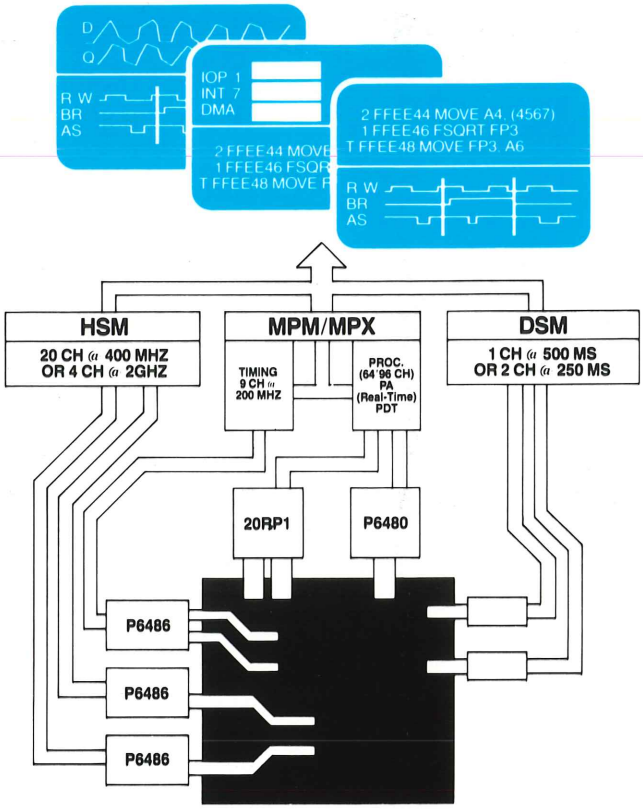


Figure 1. *A card-modular architecture tightly integrated by the TEKLink bus and a single system clock allows various tools to be cross-triggered and acquired data to be displayed in various time-correlated combinations.*

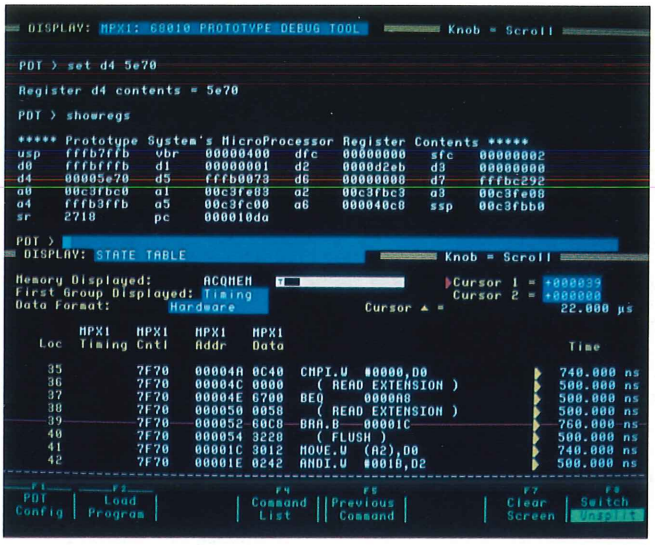


Figure 2. *Emulator-like microprocessor control functions can be used in combination with state and timing analysis, or any other Prism 3000 analysis module, to verify, analyze, and optimize hardware/software integration in single or multi-processor applications.*

all probes and provides time correlated data across all acquisition memory. As a result, data from different acquisition and analysis tools can be viewed together as a single time-correlated display. No matter what viewpoint(s) you choose for logic analysis, the results are always seen in the proper perspective.

The right tools

Whether you're analyzing hardware, debugging software, or verifying and optimizing hardware/software integration, you need the right mix of tools for the application. In most cases, this means at least state and timing analysis along with microprocessor control. With the Prism 3000 Series MPM and MPX (Microprocessor Analysis Modules), you get all of the basic tools and more.

With either the MPM or MPX module, the Prism 3000 Series provides:

- State analysis
- Timing analysis
- Emulator-like microprocessor control
- Microprocessor disassembly and analysis
- Real-time performance analysis

And, all of this is on a single tightly integrated MPM or MPX board. The only difference between the two boards is that the MPM supports 8- and 16-bit microprocessors, while the MPX supports 8-, 16-, and 32-bit processors.

The MPM/MPX state analysis section has an 8K-deep acquisition memory and supports clock rates to 33 MHz. For acquisition triggering needs, there are eight word/range recognizers, eight counter/timers, seven trigger states, and four event lines over TEKLink to other modules.

The same triggering capabilities are shared by the timing analysis section. For timing data acquisition, there are nine 200-MHz channels with 2K memory depth. Additionally, all data is transitionally stored for most efficient memory usage.

Then, still within the same module and sharing the same tight integration, there's the Prototype Debug Tool or PDT. The PDT provides emulator-like control of the system-under-test (see Figure 2). You can patch and examine registers and memory, set software breakpoints, stop and restart the system, single-step through code, and much more.

Still more power is provided through the PDT's tight coupling to other MPM/MPX capabilities. Tight coupling allows the PDT to use the state analyzer's 8K of memory as a trace buffer. Also, the PDT has access to the full MPM/MPX triggering capabilities for setting complex hardware breakpoints. Throughout, there is minimal logic analyzer interference with normal microprocessor operation. In fact, the target microprocessor can run at full speed with no wait states.

There's microprocessor disassembly and analysis, too. Software and probing packages support most popular microprocessors. No personality modules are required, and the software automatically loads and configures at power up if the necessary probe adapter is present.

Topping all of this, there are also four Performance Analysis (PA) modes. Real-Time Timing Overview and Real-Time Count Overview modes provide accurate, nonstatistical histograms of code execution times and event occurrences. Because these are real-time, nonstatistical modes, a complete picture

Figure 3. *A collapsible flat-panel display and keyboard stowage slot provide maximum mobility in the multiple-module Prism 3002 Series.*

Figure 4. *Expansion units and a color monitor allow the Prism 3000 Series to provide big-system analysis capabilities without carrying a big-system price tag.*

of system activity is created, which is extremely important in analyzing real-time control applications. For more general needs, there are also State Overview and Single-Event Measurements modes. These provide statistical overviews of system performance.

Keep in mind that all of these analysis capabilities — state, timing, PDT, and PA — are tied together in a single MPM or MPX module. They also share a single display, which allows multiple display formats to be combined on a single screen. For example a subroutine display and state table can be combined, allowing execution times for each subroutine to be seen at a glance.

In the same manner, other equally extensive and powerful modules can be used alone or combined with MPM/MPX modules for additional specialized analysis. Such modules might include high-speed hardware analysis capabilities, waveform capture and analysis, or any other tightly integrated set of analysis capabilities that future digital designs might demand.

All in the right package

Along with providing the right mix of tools for the application, the Prism 3000 Series also makes the tools available in the best package for the job. The Prism 3001MPM and 3001MPX, for example, provide the full Microprocessor Analysis Module capabilities in a single, portable logic analyzer format. That's right. State and timing analysis, microprocessor control, and performance analysis — all in a standard portable analyzer format. Plus, there's a 3.5-inch DOS format disk drive for loading software, saving setups, and transferring data to other systems.

Then, for more extensive needs, there's the Prism 3002 platform (Figures 3 and 4). Each platform accepts two Prism application modules, allowing two MPM or MPX modules or an MPM/MPX combination to be used for dual-processor applications. Or, for that matter, any available application modules can be combined in the tightly integrated Prism 3000 Series environment. For even more extensive needs, four two-module expansion units are available, allowing up to ten tightly integrated modules to be used in a single Prism 3000 system. Depending on the specific Prism 3000 configuration, additional support is also provided with an internal hard disk and printer interfacing.

With all of these capabilities and configurations available in a single tightly integrated system, there are no more barriers to efficient logic analysis — even in multiple processor systems. In fact, the only thing left for you to do is to define your toughest logic analysis problem, whether it's in hardware, software, or system integration. Then call your local Tektronix Field Office or sales representative for a Prism 3000 Series solution. U.S. customers can call the Tektronix National Marketing Center toll free — 1-800-426-2200. See your visible edge in action!

A new standard of performance ... The 2782 Microwave Spectrum Analyzer

Ken Dawson
Product Marketing Manager
Microwave and RF Instruments
Tektronix, Inc.

The 2782 is at home in the field as well as on the bench. Here, a rackmounted 2782 is used in manufacturing to test insertion loss of the bandpass filter used in a microwave IF assembly.

The Tektronix 2782 Microwave Spectrum Analyzer significantly extends the state-of-the-art in microwave analysis. It does this by extending or improving performance for every major aspect of spectrum analysis — i.e., frequency range and overall dynamic range. It truly offers a new standard of performance for design, installation, manufacturing ATE, and service activities in pulsed RF and broadband communication applications.

Precedent setting performance

While the 2782 is a portable spectrum analyzer similar in size and shape to other Tektronix portable spectrum analyzers, the resemblance ends there. Portable no longer means that you have to give up performance for portability. The 2782 incorporates completely new technology in a completely new architecture. Extensive use of surface mount technology and multilayer boards has allowed unprecedented levels of performance, functionality, and ease-of-use to be compressed into a convenient, portable package.

Extended measurement range

The 2782 offers a 100 Hz to 33 GHz coaxial frequency range with fundamental mixing to 28 GHz. No other spectrum analyzer comes close to these capabilities. Fundamental mixing to 28 GHz means lower conversion loss in the mixer for improved sensitivity at higher frequencies. Fundamental mixing also improves basic stability (residual FM).

The wider coaxial range provides more measurement range without resorting to complex external mixer setups. Coaxial input also has the benefit of wider dynamic range resulting from use of an internal attenuator and preselector convenience for eliminating internally generated spurious responses.

Improved dynamic range

The 2782 provides improvements in all areas of dynamic range. This is important because, depending upon the application, one or more of several major specifications can affect the dynamic range. These include:

- **100 dB display dynamic range:** Display dynamic range is the range over which the largest and smallest signals can be simultaneously viewed (the log amplifier's range).
- **3 Hz to 10 MHz resolution bandwidth (6 dB) in a 1-3-10 sequence:** The 3 Hz resolution bandwidth is usable to 28 GHz. It provides enhanced close-in dynamic range for phase noise, spurious, and sideband measurements.

  The 10 MHz resolution bandwidth improves dynamic range for signals with wide occupied bandwidths, such as pulsed RF and broadband communications. It also allows signal modulation characteristics to be passed with higher fidelity. This means more signals can be measured directly in zero span with the 10-MHz bandwidth.
- **0-dBm, 1-dB compression point:** Historically, the 1-dB compression point has been the primary limitation to the allowable IF gain-to-RF attenuation ratio. This ratio determines how hard the mixer can be overdriven. The 2782 can be overdriven by as much as 30 dB.
- **+15-dBm third-order intercept point (TOI):** A TOI of +15 dBm below 6.5 GHz and +10 dBm above 6.5 GHz means that the distortion products resulting from two signals at –30 dBm will be –90 dBc and –80 dBc, respectively.
- **Single-sideband phase noise:** At higher frequencies (e.g., 18 or 20

GHz), the 2782 excels by as much as 20 to 30 dB. As a result, phase noise measurements can be made directly and simply, without the very slow and costly phase noise test systems previously required.

- **Improved sensitivity:** Due to the 2782's fundamental mixing to 28 GHz, higher sensitivities are gained as compared to analyzers using harmonic mixing. The higher the frequency, the larger the improvement in sensitivity.

Built-in microwave counter

Accurate frequency measurements can be made much faster using the built-in counter because it's no longer necessary to manually center the signal and span down to the narrowest span to obtain measurement accuracy. With the 2782's counter, you simply place the marker on the signal to be counted and activate the count. Signal frequency is accurately measured, even on wide spans.

A built-in counter linked to the marker system also has several advantages over general-purpose microwave counters. Since it's closely linked to the display, you can view the signal being counted. Also, since it's linked to a high-performance spectrum analyzer, you get high selectivity, –100 dBm sensitivity, and 100 Hz to 325 GHz frequency range.

Functional display

The 2782 has a color display for clearer, easier viewing of signals and readout information (see Figure 1). Spectrum traces can be displayed in either red or green. Where two traces overlap, color mixing highlights the overlap with yellow. This use of color heightens the user's ability to quickly interpret complex multi-waveform displays. Additionally, the polarizing effect of the liquid-crystal color shutter display, provides very high-contrast viewing, making the display easy to see, even in direct sunlight.

With complex waveforms such as TV and pulsed RF, it's important to see all of the spectral detail including gray-scale information. However, many digital spectrum analyzers can't display all of these details as well as an analog system. With the 2782, however, you can simultaneously view digital and analog displays.

The 2782 also provides superb 1000 x 1000-bit digital resolution. And you can view up to four traces simultaneously. Digital averaging has also been enhanced; with the Peak/Average Cursor, you can selectively average noise while leaving the signal unaveraged.

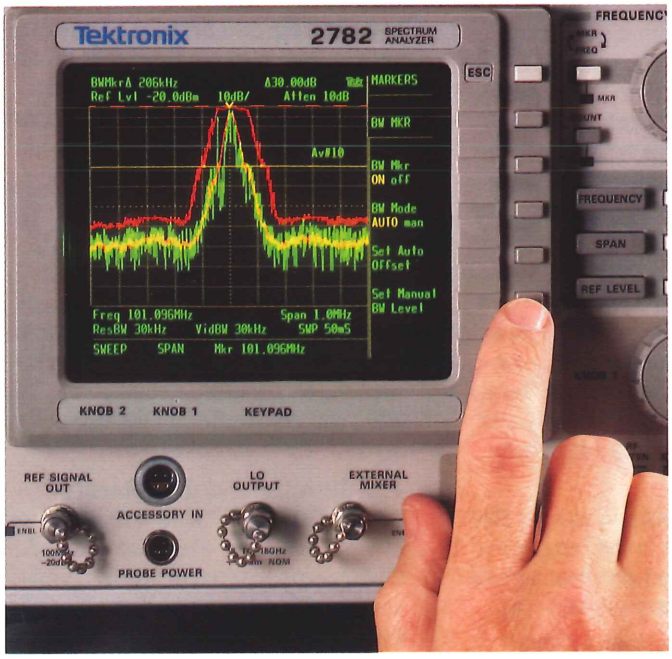


Figure 1. *Signals can be displayed in either red or green with trace overlap shown in yellow. Also notice the soft keys on the right side of the display for menu selection.*

A new human interface

The 2782 provides an optimum mix of dedicated controls and menu selection. It has a menu system that rarely goes to three levels deep. Additionally, menu depth and menu path are always shown so that you never get lost or confused. This clarity is provided by means of an overlapping menu page structure.

Menu selections are made via soft keys on the right side of the display (see Figure1). At the same time, the most commonly used functions have been maintained as dedicated functions; functions such as Frequency, Span, and Reference Level can all be controlled without ever using a menu. Most of the common marker functions also have dedicated buttons.

Another major innovation is in the way the control knobs operate. While one knob is dedicated to frequency control, the other two knobs are user assignable. A wide range of functions — Sweep Speed, Res BW, Span, Reference level, etc. — can be assigned to these knobs. This allows users to "customize" the front-panel controls to the application. Knob assignments are retained in nonvolatile memory for user convenience.

Designed for ATE

The 2782 provides two GPIB interface ports. This is of greatest potential benefit in ATE system applications. With two ports, the 2782 can use macros stored in internal nonvolatile NV RAM memory to control other equipment on one port while the ATE system controller accepts data from the 2782 on the other port.

To further enhance ATE applications, the 2782 has three built-in signal processing routines. This allows local processing of signals to ease the load on the system controller.

Continuing a long list of industry firsts

The capabilities of the 2782 Microwave Spectrum Analyzer add to a long list of industry firsts set by the Microwave and RF Instruments Division of Tektronix. These industry firsts, ranging from the first plug-in spectrum analyzer to the first portable spectrum analyzer, establish an impressive record of technological leadership for Tektronix — a visible edge in spectrum analyzer measurements.

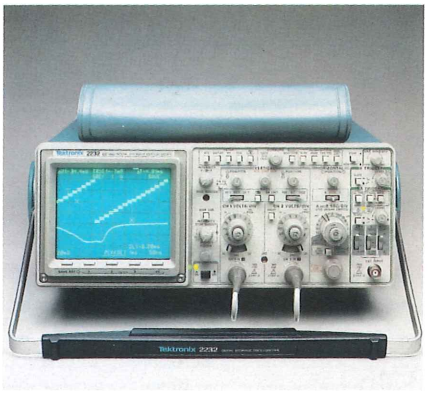
To see what the 2782 and other Tektronix Spectrum Analyzers can do for you, contact your local Tektronix Field Office or representative and ask for a demonstration. U.S. customers can call 1-800-835-9433, Ext. 1858 for information or prices. And tell them you read about the 2782 in **HANDSHAKE.**

VOL 1 NO 3, FALL 1989

TEK NEW PRODUCT UPDATE

TEST AND MEASUREMENT PRODUCTS FROM TEKTRONIX

2232 Digital Storage Oscilloscope



- 100 MHz analog and digital storage bandwidth
- 100 megasamples/second per channel sample rate
- 10 nanosecond peak detection at any sweep speed
- 4K/1K record length
- 8-bit vertical resolution
- Dual time base
- HF/LF reject triggering
- Signal averaging (weighted)
- Reformat stored waveforms
- 30K battery-backed storage for up to 29 waveform sets
- GPIB interface (with Option 10)
- RS-232-C interface (with Option 12)

Price — $5,495 (U.S.)

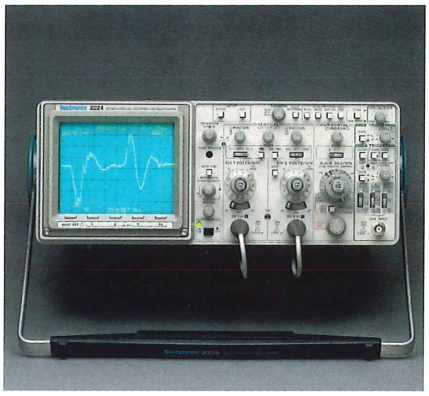
To order, or for information, call 1-800-426-2200

The Tektronix 2232 Digital Storage Oscilloscope provides 100 megasamples/second sample rates, 100 megahertz analog and digital bandwidth, and ability to capture single-shot events up to 10 megahertz. In addition, it features 10-nanosecond glitch capture capability and versatile triggering including trigger level readout for setting the precise trigger point.

These are among the features that make the 2232 an ideal tool for such applications as troubleshooting digital devices, testing microprocessor-based instruments, servicing systems containing both analog and digital signals, viewing video signals, displaying slowly changing signals such as electromechanical events, and many more.

When used with off-the-shelf software such as the Tektronix TeleServicing Support package, waveforms can be transferred via telephone modem for review by an expert at a remote location (Option 12 required). Or, up to 29 waveform sets can be stored in internal memory for reference or later analysis at the service center or other remote location.

2224 Digital Storage Oscilloscope



- 60 MHz analog bandwidth
- 10 MHz digital storage bandwidth
- 100 megasamples/second per channel sample rate
- 10 nanosecond peak detection at any sweep speed
- 4K/1K record length
- Signal averaging
- Trigger level readout
- 8-bit vertical resolution
- Dual time base
- GPIB interface (with Option 10)
- RS-232-C interface (with Option 12)

Price — $4,495 (U.S.)

To order, or for information, call 1-800-426-2200

The Tektronix 2224 Digital Storage Oscilloscope provides a high sampling rate and 10-nanosecond glitch capture capability which is ideal for applications such as electromechanical and biophysical measurements. Because single-shot capture is of prime importance in these applications, the 2224 offers a peak detection mode with glitch capture capabilities as narrow as 10 nanoseconds. This peak detection feature enables the capture of signal details at any sweep speed. In addition, the roll/scan modes permit display of slow speed events down to 5 seconds/division, an important capability for monitoring slowly changing phenomena such as temperature over time. Simultaneous sampling of both input channels allows the capture of both the stimulus and response signals — a feature particularly useful in biomedical applications such as muscle fiber research.

Buttons on the CRT bezel allow easy access to saving and recalling waveforms as well as quick selection of the available menu options. On-screen measurement cursors save time and promote measurement accuracy.

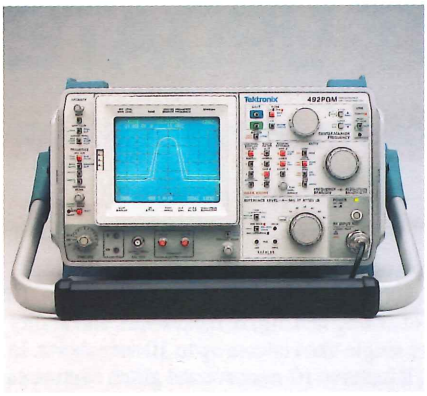
Produced by the HANDSHAKE Group, Tektronix, Inc., Group 157 (M/S 94-150), Box 4600, Beaverton, OR 97076, (800) 835-9433, Ext 157.

For additional information on products and services listed in this edition of the New Product Update, use the reply card in the accompanying issue of **HANDSHAKE** or call your local Tektronix field office or sales representative. Tektronix has field offices or sales representatives located in major cities around the world. For the location of the nearest Tektronix sales office, check your local phone book or call (503) 627-7111.

YOUR VISIBLE EDGE

Tektronix®
COMMITTED TO EXCELLENCE

492PGM Programmable Spectrum Analyzer



Price — $19,900 (U.S.)

To order, or for information, call 1-800-426-2200

- **10 kHz to 21 GHz frequency coverage**
- **±100 kHz frequency measurement accuracy at 10 GHz**
- **80 dB dynamic range**
- **1 kHz to 1 MHz resolution bandwidths**
- **Intelligent amplitude and frequency markers**
- **Full programmability**
- **Meets MIL-T-28800 Type 3 Class III environmental specifications**
- **Hardcopy output to Tektronix HC100 Plotter**
- **Non-volatile storage for nine waveforms and front-panel control setups**
- **Built-in signal processing**

The Tektronix 492PGM Programmable Spectrum Analyzer is a cost-effective instrument for spectrum measurements in applications such as terrestrial microwave system maintenance, military system maintenance, commercial television, satellite system maintenance, and RFI/EMI measurements. Full GPIB programmability lets you automate your spectrum analysis measurements. Software programs are available from Tektronix for use with the Tektronix PEP-Series controllers or other IBM PC™-compatible controllers.

The compact size and rugged construction of the 492PGM makes it ideal for on-site measurements. The 492PGM is part of the Tektronix 490-Series of portable spectrum analyzers which offer a wide array of price/performance alternatives for your measurements.

497P Programmable Spectrum Analyzer

Price — $25,000 (U.S.)

To order, or for information, call 1-800-426-2200

- **100 kHz to 7.1 GHz frequency coverage**
- **1 kHz frequency measurement accuracy at 1 GHz**
- **Built-in signal counter with 144 DB dynamic range**
- **90 dB dynamic range**
- **100 Hz to 3 MHz resolution bandwidths**
- **Intelligent amplitude and frequency markers**
- **Full programmability**
- **Meets MIL-T-28800 Type 3 Class III environmental specifications**
- **Hardcopy output to Tektronix HC100 Plotter**
- **Non-volatile storage for nine waveforms and front-panel control setups**

The Tektronix 497P Programmable Spectrum Analyzer provides a cost-effective spectrum analysis solution for applications such as mobile/cellular radio, common carrier measurements, avionics communications equipment, satellite communications, RFI/EMI measurements, consumer electronics (e.g., microwave ovens), and quasi microwave. Full GPIB programmability lets you automate your spectrum analysis measurements. Software programs are available from Tektronix for use with the Tektronix PEP-Series controllers or other IBM PC™-compatible controllers.

The compact size and rugged construction of the 497P makes it ideal for on-site measurements. The 497P is part of the Tektronix 490-Series of portable spectrum analyzers which offer a wide array of price/performance alternatives for your measurements.

DM 5110/DM 511 Digital Multimeter

Price — DM 5110 $895 (U.S.)
DM 511 $745 (U.S.)

To order, or for information, call 1-800-426-2200

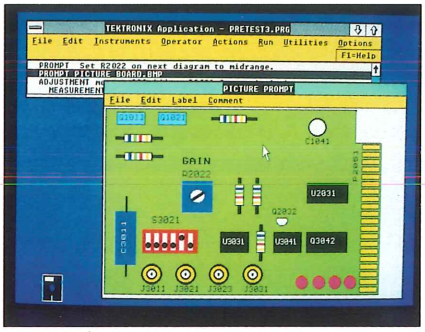
- **4 1/2 digits with autoranging**
- **3 1/2 digit operation selectable for faster measurements**
- **AC/DC volts and current**
- **True RMS measurements**
- **Resistance, temperature (with optional probe), dBV, dBM, and dBr measurements**
- **Null and hold modes**
- **Hi/Lo/Pass limit testing**
- **Compare mode with beeper**
- **Greater than 25 readings/second over GPIB in 3 1/2 digit mode**
- **Single-width TM 5000/TM 500 modular plug-in**
- **DM 5110 fully programmable from front panel and GPIB**

The Tektronix DM 5110 Programmable Digital Multimeter and DM 511 Manual Digital Multimeter are the latest additions to the TM 5000/TM 500 family of modular instruments.

Both the DM 5110 and DM 511 work well on engineering lab benches, service test stations, or in education/training labs. With it's easy-to-use front panel, compact size, and adherence to Tektronix human-readable Codes & Formats for GPIB, the DM 5110 is the perfect fit for benchtop ATE (Automatic Test Equipment) applications. In addition, the DM 5110 is a compatible and convenient DMM for any EZ-Test PC or TekTMS software based test system.

The DM 5110 is compatible with the Tektronix TM 5000 programmable mainframe; the DM 511 is compatible with the TM 500 and TM 5000 mainframes (manual mode only). Either instrument can be combined with over 50 TM 500/TM 5000 modular test instruments to form a complete stimulus and measurement system.

Tektronix Test Management System Software



Typical TekTMS graphic display for user prompts

Price — S3FT100, $2,500 (U.S.)
S3FT200, $495 (U.S.)
S3FT300, $495 (U.S.)

To order, or for information, call 1-800-426-2200

- **Runs under Microsoft Windows™**
- **Outline-view procedure generation**
- **Context-sensitive on-screen help**
- **Waveform acquisition, processing, and display**
- **Stores waveform data as waveform variables**
- **Procedure flow control**
- **String, numeric, and waveform variables similar to BASIC**
- **String and math functions**
- **Picture displays assist test operators**
- **Adjustment display speeds up interactive calibration adjustments**
- **Front-panel libraries for VXI and GPIB instruments**

Tektronix Test Management System (TekTMS) is a Microsoft Windows™-based software package for repetitive test software development and execution. TekTMS consists of three software components: Interactive Procedure Generator (S3FT100), VXI Instrument Front Panel Library (S3FT200), and GPIB Instrument Front Panel Library (S3FT300).

TekTMS develops automated test programs for board and module test in manufacturing, repair/rework facilities, and product evaluation testing. Software instrument front panels create test steps and interactively control on-line instruments. Operator prompt steps provide a graphic display to assist in component or adjustment location. An interactive adjustment step display provides real-time feedback of the current adjustment compared to nominal and high-low test limits.

TekTMS runs on Tek VXI system controllers, PEP300-Series controllers, or other IBM-PC/AT™-compatible controllers.

VX1405 C-Size VXI Mainframe

Price — $3,600 (U.S.)

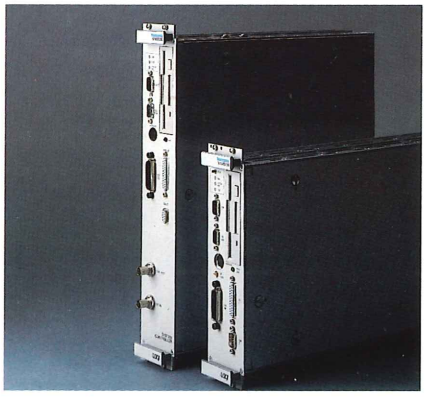
- **Five C-size VXI slots**
- **Fused backplane protects power supply from damage**
- **Variable speed fans adjust air flow to cooling requirements**
- **Auto-sensing power supply accommodates line voltages from 90 to 260 volts, 50 to 60 Hz without switching**
- **Conforms to VXIbus standard**
- **Horizontal, vertical, or rackmountable options**
- **Designed for portability, for use in the field, on a benchtop, or on the manufacturing floor**

The Tektronix VX1405 C-Size VXI Mainframe provides five C-size VXI slots for Tektronix VXI modules, VXI modules from other vendors, or custom-designed VXI modules. The VX1405 can be used in a horizontal position for bench or rackmounting. The removable carrying handle and stabilizing feet allow use in a vertical position for portable or bench use.

The C-size VX1405 is ideal for developing benchtop ATE systems. Since it conforms fully to the VXIbus standard, modules from various vendors can be used along with custom-designed modules to tailor the system to your specific testing needs. In addition, the VX1405 can be used as an expansion chassis along with existing C- or D-size VXI systems.

The VX1405 is fully compatible with the previously introduced Tektronix VX1500 D-Size VXI Mainframe. Tektronix offers a growing family of VXI products including mainframes, system controllers, counter/timers, digital multimeters, waveform generators, and VXI development systems.

VX4530- and VX5530-Series Embedded System Controllers



Price — VX4530 $11,750 (U.S.)
VX4535 $17,500 (U.S.)
VX4530 $17,900 (U.S.)
VX4530 $23,900 (U.S.)

VX4530 and VX 5530
- **16 MHz Intel™ 80386 processor**
- **2 Mbytes RAM**

VX4535 and VX5535
- **20 MHz Intel™ 80386 processor**
- **Math coprocessor**
- **8 Mbytes RAM**

Both VX4530- and VX5530-Series
- **40 Mbyte hard disk**
- **1.4 Mbyte 3.5-inch floppy disk**
- **Includes keyboard, mouse, and VGA display**
- **2 Serial ports**
- **Parallel port**
- **GPIB port**
- **Runs MS-DOS™-compatible software**
- **Conforms to VXIbus standard**

The Tektronix VX4530-Series (C-Size) and VX5530-Series (D-Size) Embedded System Controllers create a system that can use generic MS-DOS™-compatible software, access the appropriate level of VXIbus advanced instrumentation resources, and address the full A32/D32 (4 gigabytes) of VMEbus memory space.

Compatibility with the vast library of MS-DOS software means that you can use available, proven test software to implement your VXI test system. This includes Tekware measurement software packages from Tektronix such as TekTMS Software, Tek EZ-TEST, SPD Software, and GURU along with LabWindows™ and DADisp™.

The VX4530- and VX5530-Series fully implement the VXIbus standard and can be used with any compatible systems. Tektronix offers a growing family of VXI products including mainframes, system controllers, counter/timers, digital multimeters, waveform generators, and VXI development systems.

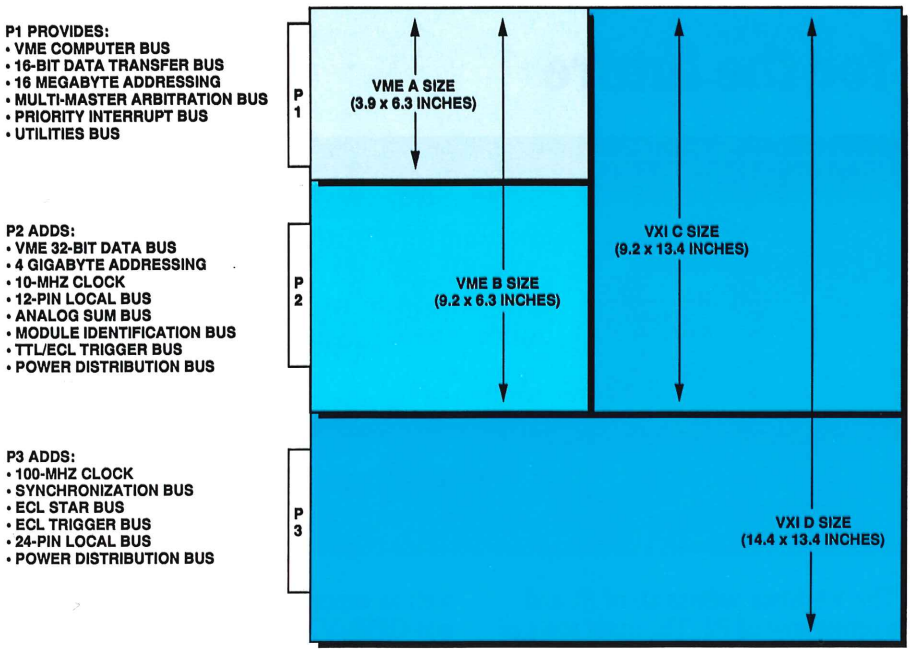


Figure 1. *Detail of the VXI board standard.*

Tektronix VX4530/5 (C-size) and VX5530/5 (D-size) controllers link the Intel 80386 processor and the PC/AT architecture to the VXIbus. This linkage results in a family of controllers which use PC software, all of the advanced instrumentation resources of the VXIbus, and address the full A32/D32 VMEbus memory space. Additionally, these VXI system controllers provide GPIB Controller and Talker/Listener capabilities.

The VXI system controllers implement Slot 0, Resource Manager, and Message Manager functions. Available with either a 16 or 20 Mhz CPU. Each Tek VXI system controller comes standard with a PC/AT style keyboard, a VGA color monitor, a serial mouse, and software. Also standard are a parallel printer port, a GPIB port, and two RS-232-C ports. Software supplied with each controller includes: TekTMS, DOS 4.1, Microsoft Windows 386, C and Basic Compilers, and VXI/GPIB Communication System.

For situations where an external controller is appropriate, Tektronix provides a slot 0/resource manager, 488 to VXI interface module; VX5520 D-size and VX4520 C-size. These controllers interface to a Tektronix PEP controller to give the user a complete VXI development environment.

VXI instrumentation

Tektronix is committed to offering an ever expanding range of VXIbus instrumentation. Currently available modules include:

- **The VX5260 Waveform Digitizer** is a D-size, compact, high performance, 200 megasample/second acquisition rate, dual-channel Waveform Digitizer which uses the instrumentation resources of the VXIbus. Five recording modes emphasize the versatility and power of the VX5260 for both manufacturing ATE and high-speed data acquisition applications.
- **The VX5790 Arbitrary Waveform Generator (AWG)** generates complex waveforms for use as unit-under-test stimulus. These waveforms include common functions such as sine, triangle, or square waves, or arbitrary waveforms derived from complex mathematical functions or recreated waveforms downloaded from a digitizer.
- **The VX4236 Digital Multimeter** is a C-size, 6.5 digit full function Digital Multimeter providing DC Voltage, AC Voltage, and resistance measurement capability.
- **The VX4223 Counter/Timer** C-size, dual-channel, 16 MHz (option to 1.36 GHz) Counter/Timer module features fourteen measurement functions including phase and pulse parameters, rise and fall times, and frequency profiling.
- **The VX4440 Scanner Master Digital I/O** controls relay cards which route signals between the test instruments and the DUT. The Scanner Master provides the necessary control signals for Tek's TSS4x series of relay drivers, switch cards, and modules.
- **Development and Prototyping Modules** are available in B (VX1321), C (VX1421), and D (VX1520 and VX1521) size modules. These devices provide a hardware and software interface from your custom hardware to the VXIbus backplane.
- **Future product introductions** will include more instrumentation and mainframe options.

VXI software

- **TekTMS (Tektronix Test Management System)** is an integrated test software development and execution system. TekTMS uses a standard MS-DOS Windows user interface to provide an effective test procedure development environment for GPIB and VXI systems. Software-based instrument front panels control instruments interactively to create control steps in the test procedure. TekTMS runs on embedded VXI controllers as well as external controllers such as the Tektronix PEP300-Series or other IBM PC compatible controllers. Optional libraries of VXI and GPIB software instrument front panels are available.

Consider the possibilities

Advent of the VXIbus standard is expanding the possibilities for using ATE. Downsized testing modules linked via high performance VXI architecture and user responsive, integrated TekTMS software are capable of increased test functionality over monolithic predecessors. The Tektronix VXI product line captures the promise of VXI — lower cost, higher performance test solutions.

For more information on the Tektronix line of VXIbus products, contact your local Tektronix Field Office or System Specialist. U.S. customers can call the Tektronix National Marketing Center toll free — (800) 426-2200. And tell them you read about the Tek VXIbus in **HANDSHAKE.**

3-D analysis of interleaved harmonic signals

Doug Goodman
Marketing Manager
Digital Signal Processing Unit
Tektronix, Inc.

A difficult measurement encountered in multimode radar systems is analyzing interleaved harmonic signals. This application describes how the Tektronix 3052 Digital Spectrum Analyzer can perform rigorous three-dimension (3-D)* analysis on these hard-to-measure signals. The signals shown are baseband as might be encountered in a down-converted RF signal. The 3052 can make measurements on baseband signals up to 10 MHz (to 2 MHz real-time).

A typical input signal, viewed in the time domain, is shown in Figure 1. It's composed of alternating bursts of 20 kHz and 30 kHz square waves with 10% duty cycle. Each burst has a duration of 10 milliseconds. The resulting amplitude spectrum in the frequency domain output is shown in Figure 2

When a square wave is converted to the frequency domain, it consists of an infinite series of harmonics. As a result, the harmonics of the two square waves, which have different and alternating frequencies, appear interleaved. The individual components of each square wave are hard to separate and difficult to measure. However, complex signals such as this can be easily separated using the 3052 Block Capture mode. This allows accurate measurements to be made on each signal.

Color spectrogram display

Figure 3 shows two display windows. The upper window was obtained in the Color Spectrogram mode and shows a color spectrogram analysis of the input signal in terms of frequency, time, and amplitude. Consider each column (or bar) in the spectrogram to represent the input signal during a specific time period.

Amplitude of the input signal is represented by changes in color — higher amplitude is shown by brighter colors and less amplitude by subdued colors. The amplitude/color reference is shown as a stacked bar chart at the right of the display.

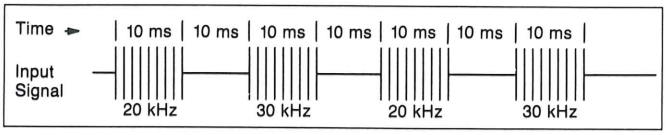


Figure 1. *Typical input signal showing interleaved 20 kHz and 30 kHz pulses (simulation).*

Spacing between the columns (or bars) represents frequency of the input signal. Horizontal axis of the spectrogram is scaled in frequency (for this spectrogram, the limits are 0 Hz and 2 MHz). The vertical axis represents time; the latest acquisition is shown at the bottom with earlier acquisitions shown above.

Notice that the columns are not aligned vertically with the row above or below. This indicates the changing spectral content of the input signal with time; i.e., components of the input signal change with time.

The bottom window shows the spectrum of the portion of the signal "flagged" by the red marker at the left side of the upper window. This marker can be moved throughout the display to display specific portions of the spectrum. As the marker is moved upward, the display is moved backward in time to recall earlier spectrums.

Further analysis of bursts

Figure 2 shows the 3052 operating in the Amplitude vs Frequency mode with the alternating bursts of 20 kHz and 30 kHz square waves applied.

This display shows the harmonics contained in the two bursts. They are interleaved but clearly shown as distinct frequency components. The 3052 display reveals information about the signal that cannot be shown by most conventional FFT spectrum analyzers because they lack the necessary frequency resolution and dynamic range.

The display in Figure 2 is a fairly typical spectrum analyzer display of the interleaved 20 kHz and 30 kHz square wave. It's possible, but very tedious, to determine which spectral line is related to which burst using this display. However, since the 3052 can display the input signal as it occurs over time, resolving interleaved harmonics becomes a relatively easy task.

Figure 4 shows a spectrum of the input signal as it exists during the 20 kHz square wave burst using the Spectral Display mode of the 3052. This isolated spectrum clearly shows the relation of the fundamental and its harmonics.

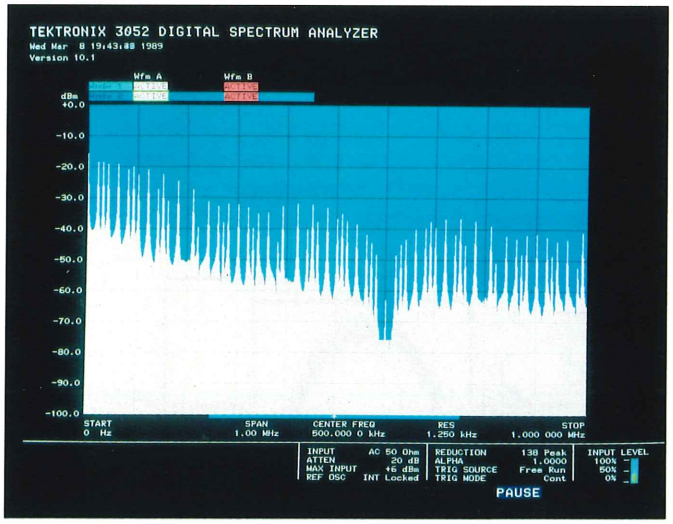


Figure 2. *Normal spectrum of interleaved 20 kHz and 30 kHz square wave bursts. It's difficult to determine which frequency components are related to each square-wave burst from this display.*

* Three dimensional with amplitude, frequency, and time characterization of the signal.

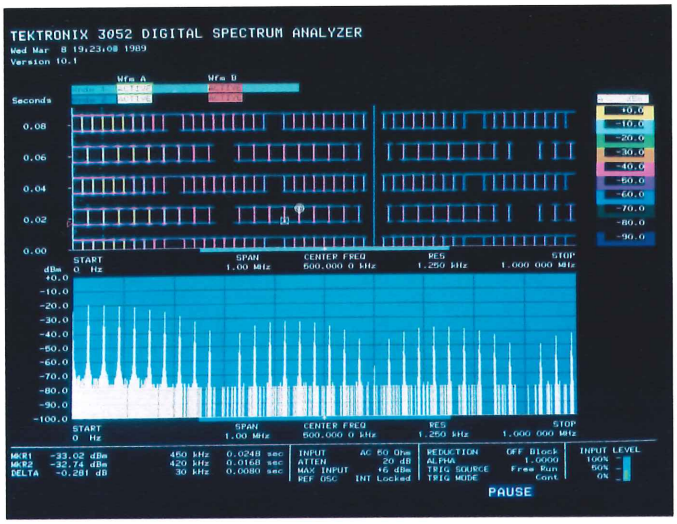


Figure 3. *Top window shows a color spectrogram of the input signal in terms of frequency, time, and amplitude. Bottom window shows the spectrum corresponding to the red marker on the left side of the upper window.*

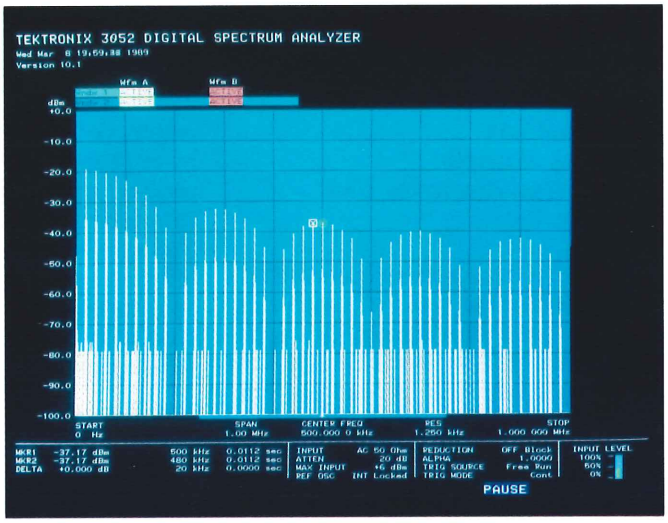


Figure 4. *Spectrum of the 20 kHz burst as isolated by the 3052. A similar display can be obtained for the 30 kHz burst.*

Individual spectrums of interleaved pulses can be separated as follows:

- Trigger the 3052
- Pause
- Scroll the 3052 through the display memory to the location of a 20 kHz burst spectrum
- Examine the 20 kHz display
- Scroll to the location of a 30 kHz burst spectrum
- Examine the 30 kHz display

Triggering in the time domain

The 3052 can be set to trigger on a variety of input conditions:

- Continuous
- Start
- Single-shot

Each of the modes has scope-like arming conditions, trigger slope control, and polarity selections. These flexible triggering modes are useful in selecting the particular zone on an input signal to transform to the frequency domain and analyzer.

In addition, the 3052 has signal gating capabilities to further aid in signal analysis.

Spectral event detection

With Option 10, the 3052 can also provide a means of selectively triggering in the frequency domain to capture and analyze elusive spectral transients. Using spectral event detection, the incoming signal (after frequency transformation) is continuously compared against a user-defined detection mask or envelope (see Figure 5). Signals that go outside the mask area are detected.

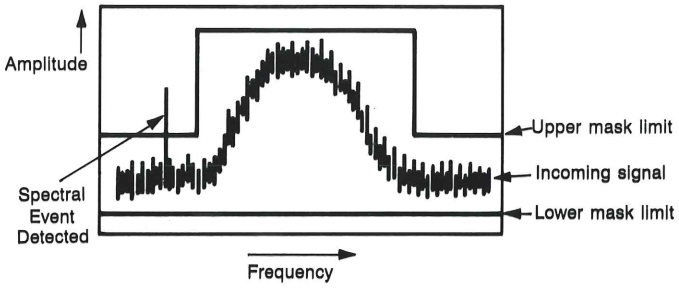


Figure 5. *Spectral event detection using a user-defined mask.*

Available for other applications

This is only one of many applications of the 3052 Digital Spectrum Analyzer. For additional information or a demonstration, contact your local Tektronix Field Office or representative. See for yourself the visible edge that the 3052 can provide in your measurements. And be sure to tell them you heard about the 3052 in **HANDSHAKE.**

Figure 6. *The 3052 can be used in conjunction with the 2782 Microwave Spectrum Analyzer for rigorous modulation tests.*

Taking the plunge into DSOs

Digitizing Storage Oscilloscopes (DSOs) have become important test and measurement tools because they offer some features that you just can't get from an analog scope. Not only will a DSO capture and store a waveform, it will analyze it and make a hard copy.

If you are thinking about moving from analog scopes to a DSO, don't throw away what you know about analog scopes. Many of the critical performance specifications don't change at all. And you don't have to compromise basic scope performance to get the special capabilities of a DSO.

First, let's consider what makes a digital scope different from its analog counterpart. Figure 1 shows the basic block diagrams for an analog and a digital scope. The DSO captures waveform data with an analog-to-digital converter and stores it in memory. Once the waveform is in memory it can be processed by the microprocessor(s) using a limitless variety of software techniques.

Choosing the right tool

Because digital and analog scopes do the same basic task — letting you see your signals — it's important to have some guidelines that will help you decide which is the right choice for the measurements you're making. Sometimes the decision between analog and digital is not an easy one. Figure 2 provides a decision tree that may get you started.

Fundamentally, there are three basic questions to consider when you're considering changing from analog scopes to DSOs:

- Will a digital scope do as good a job as my analog scope at capturing important events?
- Will it match my analog scope in accurately capturing and measuring my signals?
- Will it trigger as well as my analog scope?

The answers to these questions are often buried in data sheets — or not available at all. The best way to answer these questions is to put any scope you're considering to the test by using it to measure your actual signals. However before you do that, you can narrow the field somewhat by understanding the basic performance considerations of a digitizing scope. These are:

- Analog characteristics
- Digital characteristics
- Advanced features

The basic analog characteristics of ANY scope — analog or digital — are:

- Bandwidth
- Amplifier performance
- Trigger functionality
- Time-base flexibility

Add to this the following basic digital characteristics:

- Sample rate
- Vertical resolution
- Update rate
- Peak detection
- Record length

First make sure the DSO has the analog characteristics to provide the performance you need. You don't have to settle for less performance just to get a DSO.

Bandwidth and sample rate. If you're familiar with the way analog scopes have traditionally been specified, you might expect that a DSO would have the same bandwidth for both single-shot and repetitive signals. This is not generally the case. A DSO's *single-shot bandwidth* relates directly to its sample rate. The higher the sample rate, the faster the signals the DSO can capture. An analog scope has what could be considered an "infinite" sampling rate and tends to outperform digital scopes in the acquisition of high-bandwidth single-shot signals.

Like the analog scope, however, the DSO's *repetitive bandwidth* relies mainly on the speed of the scope's analog amplifiers, independent of the sample rate. Generally higher than the single-shot bandwidth, it might even be higher than the sampling rate. So be sure to look beyond the simple bandwidth specification on a DSO data sheet.

Vertical resolution. Other DSO characteristics affect what might appear to be analog performance. The vertical resolution determines the level of visual detail available and the accuracy of voltage **and** timing measurements. For

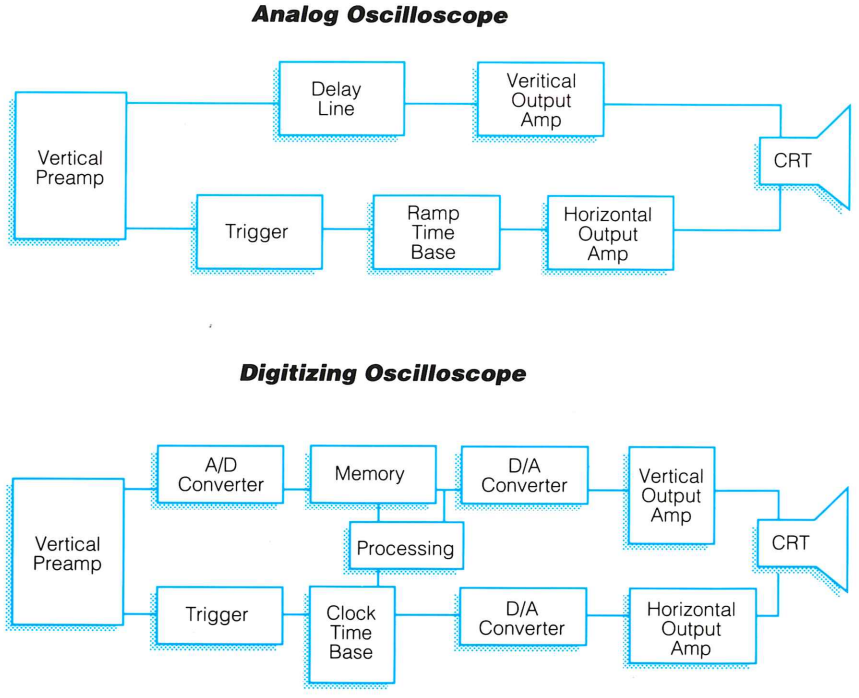


Figure 1. *Block diagrams comparing analog and digital scopes.*

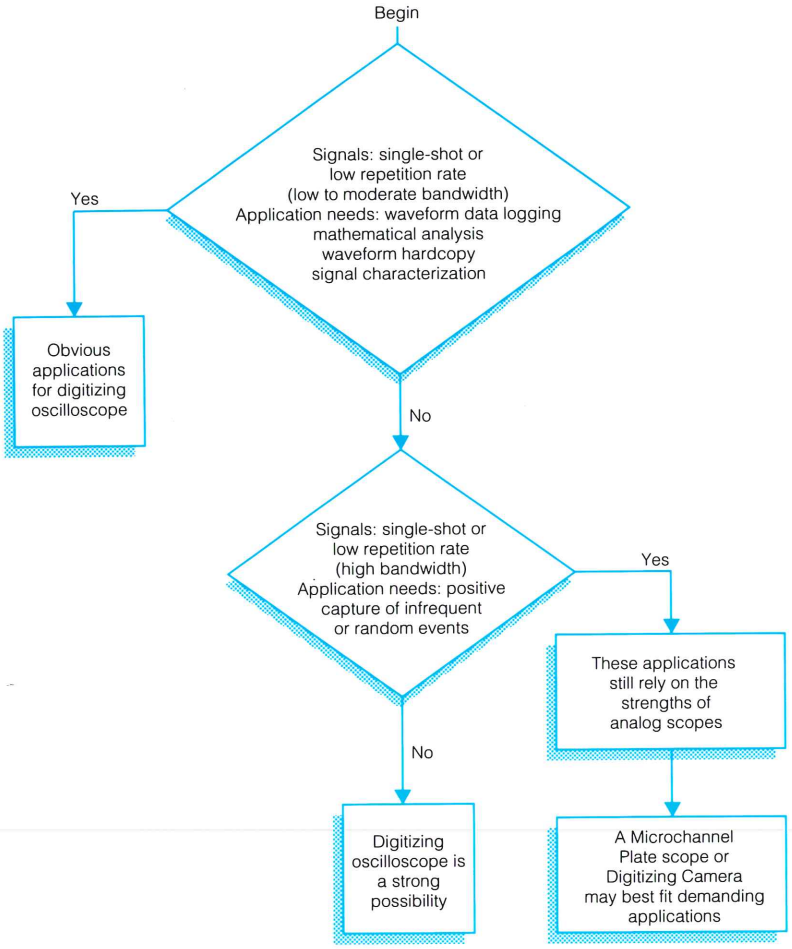


Figure 2. *Choosing the right scope isn't always easy. This decision tree should help you make that critical decision.*

many measurements, such as rise time, pulse width, and overshoot, the vertical resolution may be more critical than the sample rate. Tektronix provides at least eight bits of vertical resolution (without averaging) in its scopes because that's what most applications require.

Update rate measures how fast the scope can acquire, process, and display waveforms. With a high update rate, the scope will feel responsive, not sluggish. Low update rate decreases throughput in data logging or automatic test applications. It also reduces your chances of capturing infrequent or random events.

Peak detection ensures that you don't miss important events. It lets you operate even at slower sweep speeds without losing information that might otherwise fall between samples. Peak detection also improves a DSO's signal acquisition capabilities — allowing it to perform as if it had a much higher sampling rate.

Record length is the amount of memory available to store waveform data. Long records cost more than shorter ones, so you need to determine when long record length is truly needed and when another time function, such as Peak Detection, Delay by Time, or Delay by Events will do the job just as well.

Advanced features available on digitizing scopes add to their flexibility and ease of use. GPIB programmability and automatic measurement capabilities suit the scope to data logging and automatic test system applications. Stored setups make routine measurements available at the touch of a button. Automatic measurements and waveform mathematics use the scope's computing power to quickly provide answers without hand calculations, data transfers, or computer programming.

What's the answer?

Have you found the answer to those three questions we asked earlier? Often, the best way to answer these questions is to compare a DSO side-by-side with the analog scope you have been using. Use the signals you normally encounter to be sure that you'll get the desired results.

In some instances you'll find that DSOs aren't yet ready to provide the performance you need. For example, a high-bandwidth analog scope with a Microchannel Plate CRT will display fast single events far better than a DSO. And an analog scope with a built-in counter can measure signal timing more accurately than a digital scope. Also, an analog scope provides a real-time display of signals without frequency aliasing or the lengthy processing cycles sometimes found in digitizing scopes.

If a DSO's basic scope performance is not adequate for your signals you won't gain anything by switching. Use the guidelines in this article as well as a thorough "road test" on your own signals to be sure any DSO you're considering will do the job well and assure a successful transition.

Tek is ready when you are!

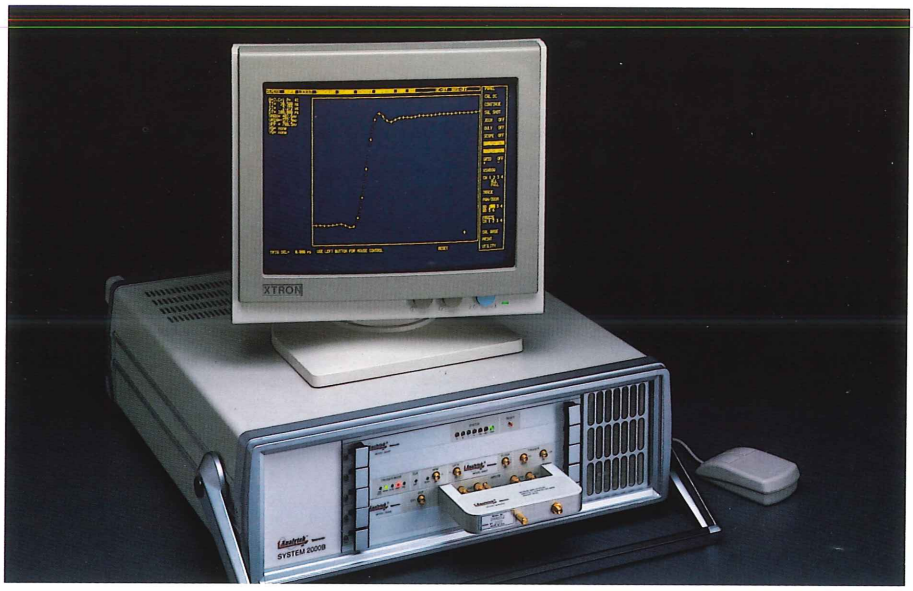
Digitizing scopes can open a whole new world of possibilities to scope users. A DSO allows you to store, transfer, or print waveforms. Numerical computations can be performed on waveforms either by the scope or in an external computer. Wave shape monitoring and pass/fail testing can be fully automated. As digitizing scope technology continues to advance, the number of applications in which you can use this power is constantly expanding.

Tek DSOs are especially suited to helping you make an easy transition from analog to digital scopes. Special digital signal processing capability, coupled with a unique operating interface based on the time-tested analog scope front panel assures you of a digital scope that operates and measures with the same reliability and ease long associated with Tek scopes.

We can help you make this difficult choice. We'll send you a special signal board to help compare digital scope performance. Just check "Scope Evaluation Kit" on the reply card in this issue.

The Analytek Series 2000 Waveform Sampler

Analytek is a Cupertino, CA company with experience in card modular instrumentation. Tektronix is marketing the Analytek Series 2000 as a complement to their existing line of Tek digitizers.



The Analytek 2000PR1 Waveform Sampler system is a complete measurement system in a compact package. Because of its flexibility, it can be expanded and adapted to a wide variety of applications.

The Analytek Series 2000 Waveform Sampling system is a very high performance card modular digitizer executed in the popular VME format. It differs from existing digitizers in several key respects; the most immediately obvious is its ability to pack a very large number of channels into a very compact package.

But more important than the number of channels is the performance. It has a maximum sample rate of 2 gigasamples/second, a dynamic range of 1500 to 1, and the highest effective bits performance of any digitizer yet available up to its bandwidth of 300 MHz. With the addition of the Series 2000, Tektronix offers a complete line of digitizers covering almost any customer application above 100 megasamples/second.

The Series 2000 is, in reality, a series of products with the card modular architecture fundamental to the overall performance of the system. The minimum configuration of the system is a three-card set: The 2000T time base and trigger module; The 2000P processing and control module; and at least one 2004S sampling module. A chassis, a monochrome monitor, and a mouse complete the minimal system configuration.

The 2000P Processing Module incorporates a Motorola 68020 microprocessor and imbedded firmware provides an extremely powerful and easy-to-use mouse-and-menu driven operating system. Data processing features include full system calibration as well as optional signal averaging, interpolation, integration, and digital filtering functions. The mouse-and-menu approach to instrument setup and data manipulation results in a truly operator friendly instrument. It's easy to learn so you'll be using the Series 2000 in record time and won't want to go back to knobs and buttons!

The 2000T Timing Module offers a full range of scope-like timing and triggering features. Access to the 1 GHz internal clock, as well as the ability to accept an external clock, are via the front panel. The 2000T provides both external and internal (free running) repetitive or single-shot trigger options, and data can be taken in either pre-trigger or post-triggr modes.

The 2004S Sampling Module contains four input channels, each with 2048 data words of memory and each capable of taking data at rates programmable up to 500 megasamples/second. Alternatively, each sampling card can be configured to function as a two-channel sampler at 1 gigasample/second with 4096 data words of memory, or as a single 2 gigasample/second channel with 8192 words of memory through the use of the appropriate signal splitter.

The Series 2000 Waveform Sampler owes its superlative performance to Analytek's patented Microstore™ analog memory unit — a fast-in, slow-out integrated circuit capable of extremely fast and accurate sampling with very low noise levels. The Series 2000 achieves a breakthrough dynamic range of 1500 to 1 based upon a 12-bit analog-to-digital converter and offers performance of seven effective bits accuracy at a signal frequency of 300 MHz. Once acquired, the data can be manipulated with the aid of powerful routines incorporated in firmware or exported for later reduction via a built-in GPIB (IEEE 488.2) port.

The 2000PR1 Waveform Sampler system is comprised of a 2000P processor, a 2000T timing module, and a single 2004S sampling module mounted in a 2000B benchtop chassis along with a monitor, mouse, and splitter. Contact your local Tektronix Field Office or sales representative for additional information including price and availability of the complete Analytek waveform sampler line. U.S. customers can call (800) 366-5060 for information.

The strength of the Analytek Series 2000 is its flexibility and expandability for multichannel applications. Watch the next issue of **HANDSHAKE** for detail of the system structure and how it can be used in a variety of applications.

CLASSES AND SEMINARS

Tektronix offers classes and seminars for the convenience of customers with application, operational, or service training needs. Workshop and class sizes are limited. We recommend that you enroll early. Other classes are planned beyond this schedule. We retain the option to cancel or reschedule classes, seminars, or workshops.

Measurement technology seminars

The Tektronix Measurement Technology Seminar provides a hands-on opportunity to explore the strengths and weaknesses of digital and analog real-time oscilloscopes side-by-side. These 3 1/2-hour seminars help to put the terminology and specifications in perspective. Seminars are designed for engineers, senior technicians, and managers concerned with selecting the right tools to improve, productivity, repeatability, and accuracy. There is no charge for these seminars, but reservations are required due to limited class space. Call the number listed below and ask for the T&M Seminar Coordinator to reserve a space today.

Wichita, KS	(913) 541-0322	Oct 9-10
Omaha, NE	(913) 541-0322	Oct 12-13
Salt Lake City, UT	(801) 977-0100	Nov 7-9
Victoria, B.C.	(604) 291-1222	Nov 14
Vancouver, B.C.	(604) 291-1222	Nov 15
Seattle, WA	(206) 885-0900	Nov 27-29
Portland, OR	(503) 620-9100	Nov 30-Dec 1
Sacramento, CA	(415) 932-4949 (Jenny)	Dec 4-5
Concord, CA	(415) 932-4949 (Jenny)	Dec 6
Oakland, CA	(415) 932-4949 (Jenny)	Dec 7
San Mateo, CA	(415) 932-4949 (Jenny)	Dec 8
Santa Clara, CA	(408) 496-0800	Dec 11-15

Seminars will be held in the Los Angles, Irvine, and San Diego area between January 15 and February 2. Contact the local Tektronix Field Office for exact dates.

Microwave measurement symposiums

Tektronix and Wiltron are jointly sponsoring microwave measurement symposiums. These one-day symposiums consist of eight technical presentations and live demonstrations designed to help customers solve difficult microwave measurement problems. There is no charge for these symposiums, but reservations are required due to limited class space. Call the number listed below and ask for the Tektronix-Wiltron Symposium Coordinator to reserve a space today.

Saddlebrook, NJ	(201) 636-8616 (Ellie)	Nov 14
Melville, NY	(516) 756-9690 (Betty)	Nov 16
Santa Clara, CA	(408) 496-0800 (Chris)	Dec 12-13

Product 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. Call Tektronix Service Training, 1-800-835-9433, Ext. WR1407 to register for the following classes.

DSA 600 Digital Signal Analyzer	Beaverton, OR	Jan 15-19
GURU II/GPIB Data Communications	Atlanta, GA	Oct 16-20
	Beaverton, OR	Nov 27-Dec 1
Personal Computer (PC) User/DOS Familiarization	Beaverton, OR	Oct 11-13
	Atlanta, GA	Oct 11-13
	Beaverton, OR	Jan 10-12
RF Spectrum Analyzer Concepts	Beaverton, OR	Nov 29-Dec 1
	Beaverton, OR	Jan 10-12
TM 500 Calibration Package	Boston, MA	Nov 6-10
TM 5000 Digital Counter/Multimeter	Beaverton, OR	Oct 30-Nov 10
465B/475A Portable Oscilloscopes	Dallas, TX	Jan 8-12
49x/275x Portable Spectrum Analyzers	Beaverton, OR	Jan 15-Feb 2
1240/1241 Logic Analyzers	Beaverton, OR	Dec 4-15
2215/2235/2236 Portable Oscilloscopes	Dallas, TX	Jan 15-19
2230/2232 Digital Storage Oscilloscopes	Beaverton, OR	Jan 9-19
2245/2246/2247 Portable Oscilloscopes	Dallas, TX	Jan 22-26
2430/40 Digital Storage Oscilloscopes	Beaverton, OR	Jan 29-Feb 9
2465/2467 Microprocessor Based Scopes	Irvine, CA	Oct 30-Nov 10
2710 Spectrum Analyzer	Beaverton, OR	Dec 4-15
7904/7633 Lab Storage Oscilloscopes	Dallas, TX	Dec 4-15
1130x Analog Programmable Scope	Beaverton, OR	Oct 16-20
1140x Digitizing Programmable Scope	Beaverton, OR	Oct 23-27
1180x Digital Sampling Oscilloscope	Beaverton, OR	Jan 22-26

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

New self-study training packages

These self-study training packages consist of a workbook, a video tape, and a signal-source board to demonstrate the signal measurement concepts.

Operating the 2211	068-0311-xx
Operating the 2224	068-0310-xx
Operating the 2232	068-0312-xx

Order self-study training packages through your local Tektronix field office or the Tektronix National Marketing Center — 1-800-426-2200. Other self-study training packages are available. For a complete listing, check the **HANDSHAKE** Reply Card.

HANDSHAKE
Group 157 (94-150)
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Beaverton, Oregon 97077

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