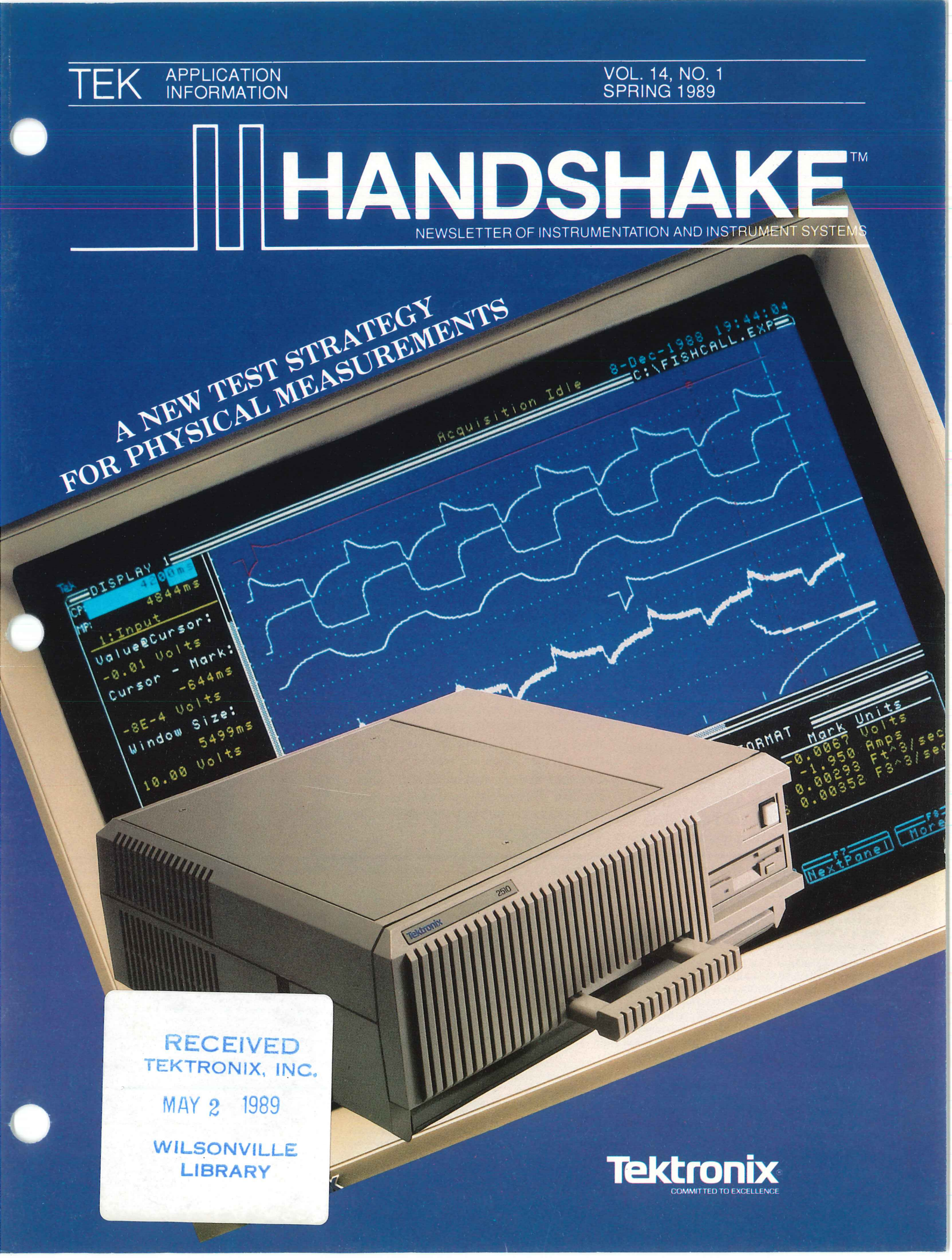
TEK APPLICATION INFORMATION

VOL. 14, NO. 1
SPRING 1989

HANDSHAKE™

NEWSLETTER OF INSTRUMENTATION AND INSTRUMENT SYSTEMS

A NEW TEST STRATEGY FOR PHYSICAL MEASUREMENTS



Tektronix
COMMITTED TO EXCELLENCE

Volume 14 — a new beginning

With this issue, we begin our fourteenth year of publishing **HANDSHAKE** — fourteen years of keeping our readers informed on new measurement instruments, processes, and techniques. We want to extend a special thanks to those of you who have been loyal readers throughout most of those 14 years. And to those of you who have just become acquainted with **HANDSHAKE**, we welcome you to our family of readers.

The past year continued to be a year of change and, hopefully, improvement in the way we provided information to you. This coming year will be no exception to change — changes that will mean more and better measurement and application information.

The biggest change is an improved focus on new products. You'll find a new section in the center of this issue; it's described in more detail in the accompanying article **A new product emphasis**.

Along with this new focus on new products, we've broadened the coverage of **HANDSHAKE** to include more test and measurement products. Starting with the new product section in this issue, we will be including coverage for products from the Logic Analyzer Division and the RF and Microwave Division, along with our past coverage for products from the Instruments Group.

If we're successful in implementation, the third change will be virtually invisible to you, our readers. In order to be more responsive to last minute editorial or product corrections and to produce **HANDSHAKE** with a minimum of resources, we've adopted desktop publishing methods for inputing and editing articles, producing many of the graphics to illustrate articles, and producing final copy for printing. For the past three years, we've used computer-based text processing and graphic tools to produce the drafts for each issue. But now, the technologies and product offerings have advanced to where we feel we can go all the way from article origination to final production using these tools. As we mentioned before, if we're successful in our implementation, you shouldn't notice the change — and we hope that's the case.

For those of you who are interested in the details, our desktop publishing system consists of an Apple Macintosh II with an E-Machines Big Picture monitor and a DataFrame XP30 hard disk. For article entry, editing, and page layout, we use Ready,Set,Go!4.5. Graphic layouts are produced with MacDraw II or SuperPaint. Often, these are used directly for the final illustrations. However at other times, the computer-generated illustrations serve as a guide for a Graphic Designer to develop the finished graphic.

We have other exciting changes planned starting with the next issue. But along with these changes, we want each issue of **HANDSHAKE** to provide answers for your measurement needs. We'd like to hear from you; let us know what you would like to see covered in future issues. Also, we welcome articles from our readers. Just check the "Article Idea" box on the reply card and we'll get in touch to help get your article idea into print.

A new product emphasis

In order to provide more information on new products in a more timely fashion, this issue of **HANDSHAKE** contains a special center section entitled **New Product Update**. This section provides information on recently introduced Tektronix test and measurement products, information on software and accessories available to help make measurements easier and more accurate, and a listing of literature and classes to keep you up-to-date and informed.

While this section is a part of **HANDSHAKE**, it can be removed and placed with your Tektronix Product Catalog or put in your product information files so you have the latest information available. Additional information on any of the products listed in the **New Product Update** is available from your local Tektronix Field Office or sales representative. Also, you can get additional product literature by checking the appropriate box on the reply card in this issue.

While we are increasing our focus on new products, feature product and application articles will continue to be a major part of **HANDSHAKE**.

Manager and Editor: A. Dale Aufrecht
Production Editor: Anita Hicks
Graphic Design: Phil Malyon

Use the reply card in this issue to request a free subscription to **HANDSHAKE**.

For information on articles in this issue or to contribute articles for publication, contact the **HANDSHAKE** Staff toll free at 1-800-835-9433, Ext. 157, or write to **HANDSHAKE**, Group 157 (M/S 94-150), P.O. Box 4600, Beaverton, OR 97076.

For more information:
United States readers can use the postpaid reply card in this issue to request a free subscription to **HANDSHAKE** or more information on products described in this issue. For product prices and information, call the Tektronix National Marketing Center 1-800-426-2200.

International readers please contact the Tektronix Sales Representative for your country. To find the address of your representative, contact the following Tektronix area offices:

Central & South America, Asia, Australia, and Japan
Phone: (503) 627-1915

France, Africa
Phone: 33 (169) 86 81 81

Federal Republic of Germany
Phone: 49 (221) 77220

United Kingdom
Phone: 44 (6284) 6000

Northern Europe Area
Phone: 31 (2503) 65265

Southern Europe Area
Phone: 41 (42) 219192

Eastern Europe and Middle East
Phone: 43 (222) 68-66-02-0

Canada
Phone: (705) 737-2700

A look inside

Physical measurements — the measurement of mechanical and electromechanical phenomena — can be a complex process. It involves gathering data from a variety of sources, processing that data, and then storing it for later use or reference. The 2510 TestLab introduced in our feature article, **TestLab — a new tool for multi-channel physical measurements**, describes a new instrument that brings together a solution to these mechanical measurement needs in one compact system.

A companion article, **Providing a total solution for shock and vibration analysis** describes a new family of accelerometers available from Tektronix. These accessories can acquire mechanical testing signals for analysis and display by the 2510 TestLab as well as for digitizing oscilloscopes such as the Tektronix 2200-Series, 2400-Series, or 11000-Series.

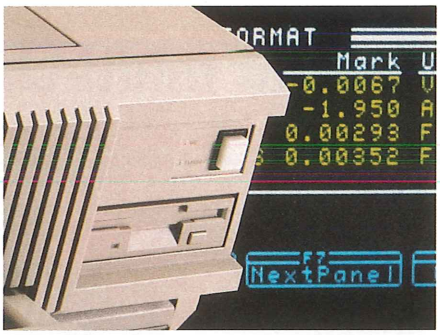
Automating digital interface testing for telecommunications looks at an important measurement area — testing the quality of signal transmission lines and systems. This application describes the 2410 Digital Interface Test System and explains the tests required to verify signal transmission integrity.

We introduced the Tektronix 11800-Series Digital Sampling Oscilloscope in the Winter 1988/89 **HANDSHAKE** and described its unique ability to make differential TDR measurements. The tutorial article **Establishing the basis for differential TDR measurements with the 11800-Series Oscilloscopes** describes the basis for making these types of measurements with the 11800-Series.

We hope you find this issue both interesting and informative. For help with any of your test and measurement applications, contact your local Tektronix Field Office or sales representative. They'll be glad to help you. And tell them **HANDSHAKE** sent you!

A. Dale Aufrecht
HANDSHAKE Editor

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



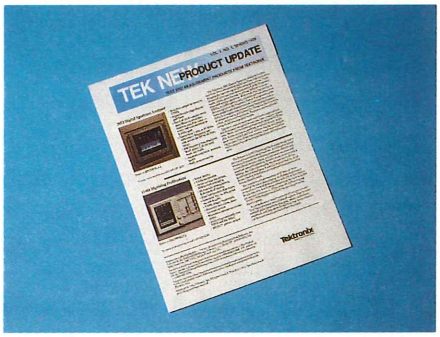


Table of contents

A new test strategy for physical measurements ..... cover

TestLab — a new tool for multi-channel physical measurements 4

Providing a total solution for shock and vibration analysis 9

New Product Update ..... center

Featuring: 3052 Digital Spectrum Analyzer, 11403 Digitizing Oscilloscope, SD-42 Optical to Electrical Converter Head, 2815 OPTO-Scope™, PFG 5105/5505 Programmable Pulse/Function Generator, 222 Storage Oscilloscope, 11201 Digitizing Oscilloscope, DM 5120/5520 Programmable Digital Multimeter, 11A72 Two-Channel Amplifier, Classes, Self-Study Packages

Automating digital interface testing for telecommunications 10

Putting "portability" into portable measurements 12

The ultimate portable digital oscilloscope 13

HANDSHAKE article index for Volume 13 14

Establishing the basis for differential TDR measurements with the 11800-Series Oscilloscopes 15

TestLab — a new tool for multi-channel physical measurements

Chuck Bublitz
Product Marketing Manager
TestLab Products
Tektronix, Inc.

The 2510 TestLab brings new capabilities and convenience to physical measurements. The portable version (shown here) can be easily taken to the measurement site.

Physical measurements on mechanical and electromechanical systems have become more complex than need be. Part of the problem is the sheer variety of measurement types and data necessary for product development and evaluation. This is driven, in part, by competitive forces. Mechanical- and electromechanical-based products have to be more efficient, more reliable, and more cost effective to survive in a global marketplace. At the same time, environmental and safety regulations continue to add to the product evaluation burden.

Not much can be done about the complexities raised by competitive and regulatory forces. If anything, product measurement and evaluation requirements will continue to increase.

But there is another part of the problem that can be directly attacked by design and evaluation engineers. This is the problem of measurement efficiency. As multi-channel measurements become more complex, engineers need to re-evaluate their environment in terms of fundamental measurement issues and how these issues can be more efficiently addressed. With the right tools, this can result in substantial simplification of complex measurement procedures.

Defining the fundamental measurement issues

An examination of the physical measurement environment reveals some universal measurement needs. Briefly, some of the more common ones are:

Multiple channels. It is common for data gathering to involve half a dozen or more time-varying parameters. Each time-varying parameter, or waveform, needs to be captured on a separate data channel. The more parameters involved in a test, the more data channels necessary for test coverage.

Differing signal types. Data channels are typically of mixed data or signal types (e.g., stress, strain, velocity, torque, revolutions per minute, etc.). A wide range of instrumentation has been developed for sensing, conditioning, and acquiring various specialized signal types. While these individual instruments may solve specific acquisition problems, the data from all instruments must still be coordinated and processed into final results.

Mixed record lengths. Within a single test or experiment, it is common to see differing record length or time resolution requirements. For example, several channels might be devoted to long-duration recording of on-going conditions leading up to material failure, and several other channels might be devoted to short-duration, high-resolution recording of failure transients. The record lengths of these mixed channels may run from milliseconds to hours. Not only must the test instrumentation be capable of covering these varying record lengths, but there needs to be some common format for viewing and analyzing the various related records.

On-line measurement verification. If measurements can be verified during tests, costly retesting can often be avoided. When multiple instruments of different types are used in a test, on-line comparison of measurement data is generally difficult and cursory at best. This is because the acquired data is usually in different formats and on different media. For example, some channels may appear on an oscilloscope display, others as chart recorder output, and still others as meter readings. Valuable time and information can be lost by the inability to make quick comparisons or parametric checks across channels.

Data storage. Because of the quantities and variety of data gathered during typical multi-channel tests, full measurement analysis is generally done off-

line, after testing is completed. Some method of data storage is required to support this. Traditionally, this storage or permanent recording function has been filled by chart recorders and magnetic tape. More recently, digital methods and computer diskettes have come into use as a more convenient method of high-density data storage.

Measurement analysis. In most instances, test data is raw sensor data. Typically, it must be processed in some manner to provide final results. This can range from simple scaling of the data to extraction of various waveform parameters representing physical quantities. If scaling, units and analysis are built into the system, these functions do not have to be performed as separate tasks after data acquisition and recording.

Data management. There are several categories of data or information that must be coordinated throughout a test. These categories include:

- Instrument setup and control information
- Measurement data
- Analysis processes
- Final results

A broader and more convenient categorization for test and measurement purposes is acquisition, processing, and display. If these data handling categories are not integrated into the instrumentation, they must be dealt with as separate issues.

Test note logging. This could actually be grouped with data management. However, recording notes with test data is a special enough process to require separate consideration. In most cases, note logging is a manual process, where the test operator simply writes information on a clip board or directly on chart recorder output.

Automation. It's becoming common to see some form of automation included in the measurement process. Typically, this is front-panel setup automation on individual instruments.

However, as tests on mechanical and electromechanical products become more complex, instruments are being linked to computers for automatic setup and acquisition control. Unfortunately, measurement automation has largely been left to the test engineer. Since this entails interfacing instruments from different vendors and writing acquisition and analysis code, overall measurement automation is generally only done in the most demanding situations. This leaves the efficiencies of automation lacking from a broad range of day-to-day applications in both the lab and the field.

TestLab provides the answer

If all of these issues could be addressed within a single instrument, multi-channel physical test and measurement could be substantially simplified. To create such an environment, Tektronix has developed the 2510 TestLab multi-channel analyzer. TestLab addresses all of the fundamental measurement issues with a fully integrated acquisition, processing, and display environment (see Figure 1). This approach brings a high level of multi-channel measurement efficiency to a broad range of multi-channel applications.

Solving the acquisition problem

To address multi-channel acquisition needs, TestLab uses a card-modular approach that supports eight channels within the instrument mainframe. Depending upon specific acquisition needs, different cards are plugged into the mainframe. For example, a 50-kHz bandwidth Four Channel Acquisition Card provides four differential analog channels with simultaneous waveform sampling on each channel. The card also includes 256K samples of waveform memory that can be used wholly on one channel for storing long waveform records, or it can be segmented across all channels.

In general use, the physical phenomenon to be measured is sensed with a conventional sensor in the normal manner. Depending upon the sensor, this may also include some kind of signal conditioning. The conditioned signal is then connected to one of the TestLab input channels. As needed for any given test, other physical phenomena are sensed, conditioned, and connected to other TestLab channels.

Once the conditioned signals are connected to TestLab, acquisition setup and control proceeds in the same manner for each channel via a common user interface. This consists of various menus and displays on the display screen for instrument setup, configuration, display, and utilities. All menu selections and subsequent data entries are made directly from the keyboard. There's no programming necessary since actual channel setup is done by direct database entry in a simple, spreadsheet-style setup table called the TestSheet.

Figure 2 shows an example of TestSheet. As shown in the left column, channels can be given convenient labels that reflect the actual type of data being

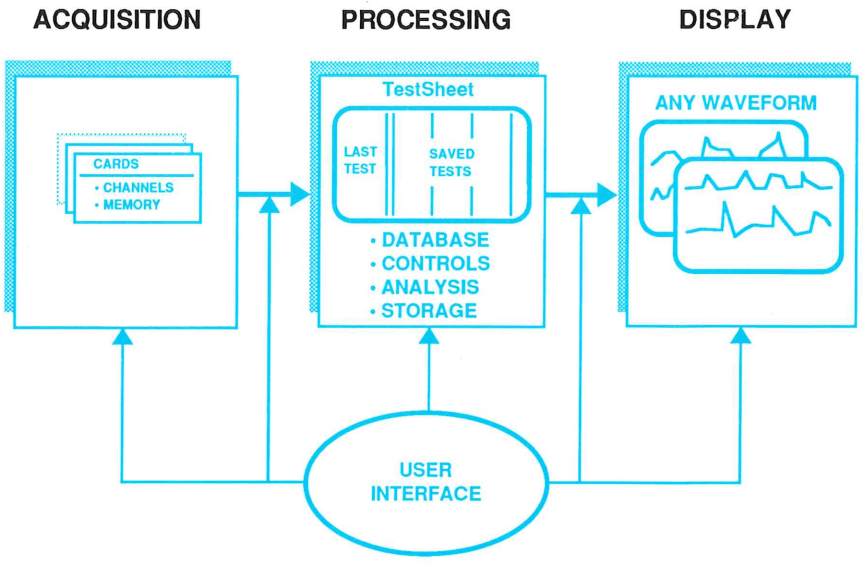


Figure 1. *The Tektronix 2510 TestLab provides user access to a fully integrated environment for acquisition, processing, and display.*

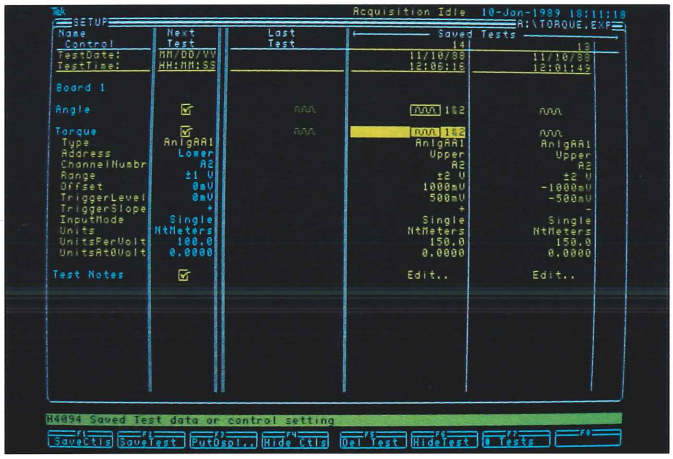


Figure 2. *Spreadsheet-style setup allows direct and simple access to control parameters for each channel as well as setup parameters used in previous test.*

acquired. Depending on the type of acquisition card being used, various setup controls are listed under each channel label. The current value of each control appears in the "Next Test" column to the right and can be changed in the same manner as making a standard spreadsheet entry — just move the cursor to the value and type in the desired new value or use the select knob to enter data.

The key point is that the basic setup process is the same for all channels regardless of the number or type of channels being used. This uniform method of setup and control provides substantial simplification and efficiency over dealing with several individual instruments.

At the same time, acquisition and control parameters are software linked to the channel acquisition card(s) in real time. Changing the Next Test value for the trigger level changes the actual physical trigger level on the card. If the setup is saved and later recalled, all control parameters in the recalled setup are automatically instituted for each channel in the setup.

Verifying measurement quality on-line

In order to verify data being acquired throughout a test, there needs to be some way to view waveforms as they are acquired. Moreover, since acquisition is typically being done in a multichannel environment, there needs to be a simple means of looking at multiple waveforms in a convenient manner with a common format for quick visual comparison.

To address waveform display issues, TestLab can be set up to provide two waveform display windows on the color monitor. Up to eight waveforms can be displayed in each window. Or as is shown in Figure 3, a selected waveform can be expanded and analyzed in detail in the second window. The cursors (shown as dashed lines) provide an additional convenience for quick on-screen measurement of waveform time and amplitude parameters.

The measurement cursors can also be linked between displays for quick comparison of parameters. This is shown in the X-Y display setup in Figure 4. In this display, torque and angular position are plotted against time in the top window. The same parameters are plotted against each other in the bottom window to provide an X-Y display. At the same time, the measurement cursors have been time-linked between the two displays. The cursors can be positioned to points of interest on the X-Y display, and they will automatically track to the corresponding points on the upper time plots of data. Also, notice the measurement parameter fields to the left of the waveform displays; all units of measure appropriate to the physical quantities are maintained. If you would like to know the area of the X-Y display, a formula channel can be set up to calculate that area.

Another capability is display of different waveform record lengths within the same display window. For such displays, a common time scale is used, allowing quick relative comparisons between waveforms acquired at various resolutions. These waveforms can be stacked, as shown in the top display of Figure 3, or one waveform can be se-

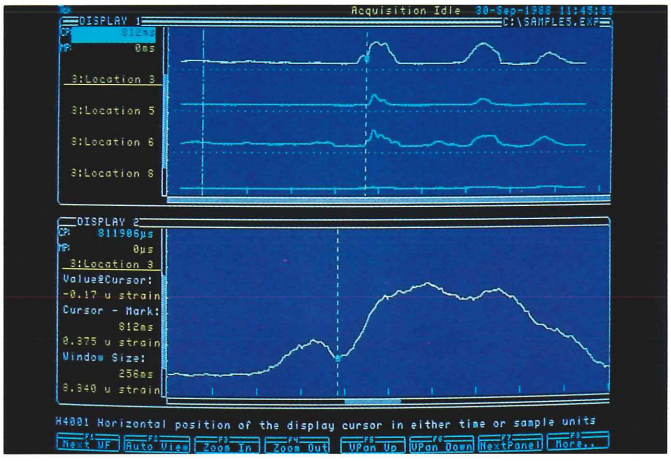


Figure 3. *Two waveform display windows are provided with capabilities for zooming, panning, and cursor measurements. The same data can be viewed simultaneously in two different display resolutions.*

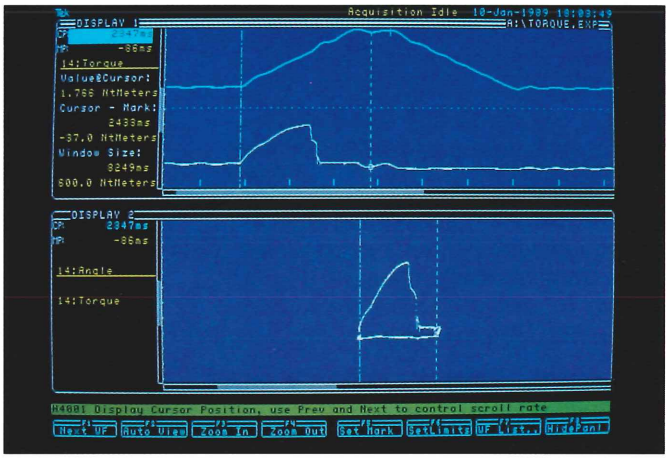


Figure 4. *Acquired data can be displayed versus time (top) or in X-Y format (bottom) with measurement cursors linked between the two displays.*

lected and moved to overlay another waveform. Additionally, waveforms can be processed with a wide range of built-in functions that include +, –, /, ^, integration, differentiation, MAX, MIN, peak-to-peak, RMS, and others. These built-in functions can also be combined for more extensive waveform processing operations.

Simplifying data management

The spreadsheet-style management of acquisition setup and control database was shown in Figure 2. This same setup screen also provides additional data management for various test runs. For example, Figure 2 shows the Next Test control details and how they compare to previously Saved Tests.

The ability to see several tests side-by-side in a compact form simplifies comparison of past tests as well as setup for the next test. As a matter of contrast, think about keeping track of the setups and sequencing for several individual test instruments. Then compare that to the efficiency of seeing all the pertinent acquisition information in the tabular form of Figure 2. Add to this, the convenience of seeing test results in a common display format such as Figures 3 and 4, and overall data management is again simplified.

To provide still more convenience and simplification, TestLab also provides several other means of data management and transfer. For example, there's a printer port that allows screens to be copied to an Epson-compatible printer (see Figure 7). This provides immediate paper documentation of test setups and results.

Test setups, results, and print screens can also be stored on 3.5-inch floppy disks that are MS-DOS compatible. This allows convenient data transfer to an IBM-compatible personal computer for further off-line processing. To assist in this, utilities are available for converting TestLab files to ASCII and Lotus 1-2-3 .WKS data formats. Or direct data transfers to other computers or systems can be done over the optional IEEE-488 interface.

Covering measurement change and growth

There are many benefits to the card-modular acquisition channel approach used in the Tektronix 2510 TestLab. For example, different acquisition capabilities can be provided by changing cards within the same instrumentation environment. This is more cost-effective and efficient than using completely separate and independent instruments for different channel requirements. And, the card-modular approach allows future acquisition enhancement. This further extends the capabilities for economical growth or reconfiguration for changing measurement needs.

A further benefit of the card-modular approach is that it allows all channels to be fully integrated into a common acquisition, processing, and display environment. This allows substantial simplification in measurement setup and data management. The same basic processes are used to control all channels. This is more efficient than learning operating procedures for various standalone instruments. The same efficiencies also apply to the common display format of TestLab. It's easier to view and interpret multi-channel data on one display, rather than trying to correlate and interpret the displays and formats of multiple instruments.

Additionally, all of these benefits can be carried to the field if needed. The fold-down flat-panel display can be ordered or added later as an optional accessory to provide a compact field unit (see Figure 5). And, with the 12-volt DC power capability, TestLab can be operated from a lead-acid automotive battery or any comparable 12-volt DC source. With these various configuration possibilities, the Tektronix 2510 TestLab multi-channel analyzer is equally at home in a field van, evalua-

Figure 5. *TestLab can be equipped with a color monitor for lab use (foreground) or a fold-down, flat-panel display (background) for portable measurements. A soft-sided carrying case is also available to make it easy to take TestLab to the measurement.*

Figure 6. *The 2510 TestLab can be used for many tests in research, manufacturing, and test. Here, TestLab is being used to monitor the quality of polycarbonate plastics used in the manufacture of compact disks. (Photo courtesy of Dow Chemical.)*

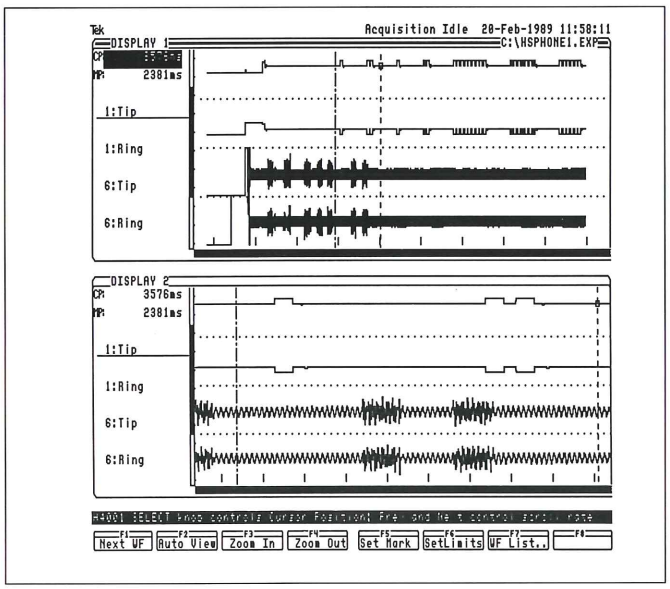


Figure 7. *Tip and ring waveforms used by telecommunications service engineers to analyze trunk line and central switch dropouts. Bottom display expands the top display to allow closer examinations of signal details. (Print Screen to Epson-compatible printer.)*

tion facility test bay, or on a benchtop in the engineering lab.

A few application ideas

The 2510 TestLab is a new type of instrument, combining many functions previously requiring multiple instruments. Many new and exciting applications will come to light as it is put to use in research and development, prototype testing, manufacturing, and many other application areas. Here are just a few application areas where TestLab is working today to start you thinking about some of the many ways that you can put it to use.

Precision injection molding. Manufacturing entertainment-quality compact disks requires an injection molding process with stringent dimensional tolerance requirements. To ensure that their product meets these requirements, the supplier of the polycarbonate plastics from which compact disks are made uses TestLab to measure, analyze, and organize data gathered during the manufacturing process (see Figure 6).

The researchers run detailed analyses with TestLab's built-in math functions. They use its database to organize multiple test runs and keep accurate, detailed records. And when they need reports including annotated plots and molding-process data analysis, they transfer their TestLab data to PC-resident documentation packages.

Magnetic recording tape. Throughout industry, engineers and researchers use multi-channel magnetic tape for data acquisition and storage. Now, TestLab gives them a way to analyze hours of magnetic tape data with ease and accuracy.

TestLab's chart recorder-like roll mode lets tape users review hours of data, while storing only what they want to save. And its database provides a convenient waveform data storage area, permitting easy reference and analysis.

Servicing telecommunications switches. Telecommunications service engineers are continually challenged to identify the source of sporadic dropouts in customer phone lines. Among the events they look for are incorrect trunk and switch timing, momentary power dropouts, and dial pulse duration and timing.

The engineers require a variety of acquisition capabilities to solve these field service problems: a multi-channel instrument that is easily configured to simultaneously monitor many trunk and central switch lines, automatic ranging and triggering, clear display of long-duration waveforms, and on-the-spot hardcopy to document the source of trouble. Of course, the instrumentation should also be portable and immune from power outages.

The 2510 TestLab provides an ideal solution. The 35-pound portable package gives the telecommunications field service engineer up to eight channels of data acquisition for capturing tip and ring signals such as shown in Figure 7. In a matter of minutes, the service engineer can configure, range, and trigger TestLab using the Autoset feature to get on with the job of analyzing timing and amplitude anomalies. By storing the waveforms in the 2510 TestSheet, a complete problem and service history can be maintained for each customer site. These capabilities make the service call more efficient, more effective, and less expensive for both the customer and the service engineer.

Circuit-breaker parameter setting. At a major industrial plant in Washington state, TestLab helps facilities engineers set and troubleshoot parameters such as continuous-ampere and ground-fault delay on 440-volt, 3-phase circuit breakers.

Engineers characterize incoming power using TestLab's multi-channel capabilities to gather properly time-correlated voltage and current values. Using formulas, they can calculate RMS and peak voltage, current, and power.

They can visually analyze voltage and current anomalies, as well as discern harmonics, on TestLab's high-resolution display. And with its automatic storage feature and an external triggering device, they can sample power over many days, constructing a picture of overall power quality.

For more information

Chances are, your application can also benefit from TestLab's multi-channel acquisition, long record-length, high resolution, integrated data management and analysis, convenient data transfer to PCs, and single-handle portability.

TestLab can be configured for two- to eight-channel capability for input bandwidth from DC to 5 MHz. This is accomplished by selecting any combination of the two acquisition cards available. These cards have 100 Ksample or 10 Msample speeds and at least 64 Ksample memories for each channel. Depending upon configuration, memory can be allocated to one channel per acquisition card for as much as 256 Ksamples each.

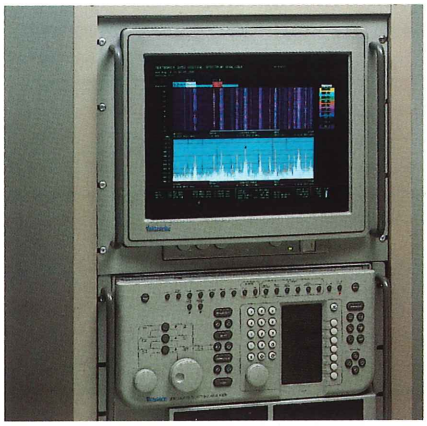
For further technical information on the Tektronix 2510 TestLab, please contact your local Tektronix Field Office or sales representative. U.S. readers can call TestLab Marketing toll free for information, prices, or to place an order — 1-800-835-9433, Ext. 2510. Be sure to tell them you read about TestLab in **HANDSHAKE.**

VOL. 1, NO. 1, SPRING 1989

TEK NEW PRODUCT UPDATE

TEST AND MEASUREMENT PRODUCTS FROM TEKTRONIX

3052 Digital Spectrum Analyzer



Price — $79,950 (U.S.)

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

- **Real time output in spans to 2 MHz**
- **Sophisticated triggering capabilities**
- **Band of 1024 complex bandpass filters outputs spectrums at real time rates — every 200 microseconds in 2 MHz span**
- **Spans from 1 kHz to 10 MHz, with center frequency tunable across the DC to 10 MHz range**
- **800 frequency bins displayed in all spans. 1.25 Hz minimum bin width**
- **Accurate amplitude measurements**
- **Fully programmable**

The Tektronix 3052 Digital Spectrum Analyzer is a fast, real-time, three-dimensional digital spectrum analyzer system designed for rigorous signal processing applications. It performs real-time spectrum analysis at much wider frequency spans, which opens the way to solving difficult measurement and analysis problems. With a real-time bandwidth of 2 MHz, the 3052 continuously digitizes and transforms time domain signals to the frequency domain for rigorous modulation analysis and characterization. Users can then look at difficult-to-capture spectral transients, frequency response, distortion products, and harmonics. These can be viewed on a three-dimensional basis (time, frequency, and amplitude) using the advanced graphic modes.

Spectrum analyzer setup and control is through a detachable front panel designed for easy use from a variety of positions. Menu-driven operation from the front-panel LCD display, keystroke macro capability, recallable setups, single-knob zoom control, and dual-window display and processing are just a few of the convenience features provided for rapidly acquiring and viewing different spectral representations.

11403 Digitizing Oscilloscope

Price — $16,950 (U.S.)

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

- **Color display**
- **1 GHz bandwidth**
- **10-bit vertical resolution, 14-bits with averaging**
- **12 channels of acquisition, 8 channels of display**
- **Dual independent time bases**
- **Selectable 512- to 10K-point record lengths**
- **1 GHz trigger bandwidth**
- **Extensive waveform measurement system**
- **Waveform measurement statistics**
- **Fully programmable over GPIB and RS-232-C**
- **HPGL™ plotter output**

The Tektronix 11403 Digitizing Oscilloscope brings a new dimension to precision measurements. A color touch-screen interface eliminates the confusing assortment of knobs and buttons found on many signal acquisition instruments and keeps the operator's attention focused on the screen where it belongs. An eight-color display lets the user easily distinguish between waveforms in a multi-channel display. In addition, window waveforms are displayed in a separate color for easy identification.

The standard vertical resolution of 10-bits can be increased to 14-bits with averaging. An Enhanced Accuracy mode allows vertical measurements with 1% or less of error. Single-shot time A to B measurements can be made with 200 picosecond resolution — 10 picoseconds with averaging. And the 1 GHz trigger bandwidth lets you trigger on the fastest signals.

A comprehensive measurement set allows you to make "live" measurements from displayed signals. This includes standard pulse parameters plus gain, phase, undershoot, overshoot, and duty cycle. In addition, waveform statistics can be automatically performed and displayed.

Supplement to **HANDSHAKE** — Test and Measurements Newsletter from Tektronix, Inc. 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 New Product Update, use the reply card in the accompanying issue of **HANDSHAKE**. U.S. readers can call the Tektronix National Marketing Center toll-free to place an order or for information — 1-800-426-2200.

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.

Tektronix®
COMMITTED TO EXCELLENCE

SD-42 Optical to Electrical Converter Head

- **55 picosecond optical pulse response (maximum FWHM)**
- **DC to 6.4 GHz equivalent bandwidth (0.35/55 ps)**
- **1000 to 1700 nanometer spectral response**
- **Calibrated at 1300 nanometers**
- **Mean optical power monitor function**
- **Optical power monitoring from 5 nanowatts to 5 milliwatts**
- **Compatible with Tektronix 11800 family**

Price — $3,250 (U.S.)

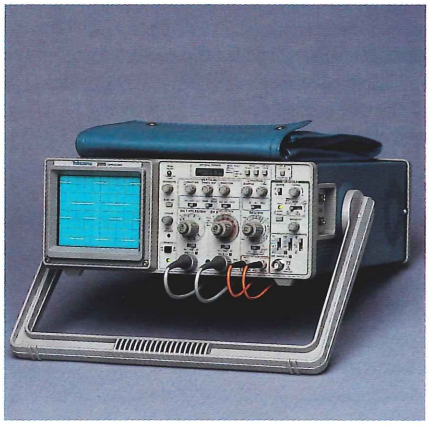
To order, or for information, call 1-800-426-2200

The Tektronix SD-42 Optical to Electrical Converter Head is designed for use with Tektronix 11800-Series Digital Sampling Oscilloscopes (including the SM-11 Multichannel Unit). It can be used to analyze optical signals in the 1000 to 1700 nanometer range. Pulse response of the measurement system is less than 55 picoseconds (Full Width Half Maximum) which is equivalent to a calculated bandwidth of DC to 6.4 GHz.

The SD-42 fits into the sampling head compartment of a 11800-Series Digital Sampling Oscilloscope adjacent to an SD-22, SD-24 or SD-26 Sampling Head. The electrical output on the front panel of the SD-42 converter is coupled to the adjacent sampling head via a semi-rigid coaxial link.

The SD-42 has an integral optical power meter for average power monitoring by an external voltmeter via a pair of voltage outputs on the front panel. A selector button on the front panel of the SD-42 selects between the microwatt and milliwatt ranges and allows measurement of power from 5 nanowatts to 5 milliwatts. Input overload warning is also provided when the optical signal is too large for the selected range in order to prevent overload.

2815 OPTO-Scope™



- **DC to 50 MHz electrical bandwidth**
- **DC to 35 MHz optical bandwidth**
- **Calibrated at 850 nanometers**
- **Operational from 450 to 1050 nanometers**
- **Integrated optical power meter**
- **Externally modulatable 850-nanometer LED source**
- **500 microvolts/division electrical sensitivity**
- **200 nanowatts/division optical sensitivity**
- **5 nanoseconds/division maximum sweep rate**
- **ST and FC connector options**

Price — $3,795 (U.S.)

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

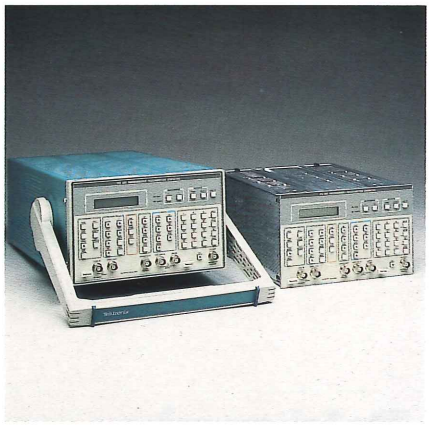
The Tektronix 2815 OPTO-Scope™ provides a unique combination of optical and electrical measurement capability. The optical system includes an optical power meter, optical-to-electrical converter, modulatable optical source, as well as CRT-based power measurement capability.

Full-function electrical measurement capability is also provided. Two channels of electrical signals at up to 50 MHz can be displayed independently, dual trace, or added. A push button switch converts Channel 2 to an optical channel. Now you can simultaneously display optical and electrical signals in real time for comparison.

Optical power is displayed on a 3 1/2 digit backlit LCD readout. Power levels can be measured in dBm or watts; relative dB measurements can also be made. The power meter is active at all times so optical measurements can be made even when the optical channel is not displayed.

A built-in 10-microwatt, 850-nanometer optical source is also provided. This is used to test the optical channel or it can be used for stimulating external optical systems. This optical source can be externally TTL modulated at rates up to 10 megabits/second.

PFG 5105/5505 Programmable Pulse/Function Generator



- **Pulse, double pulse, sine, square, triangle, and DC functions**
- **0.012 Hz to 12 MHz**
- **Programmable pulse width, period, and delay**
- **Accuracies to 0.005% with synthesizer option**
- **10 millivolts to 9.99 volts peak-to-peak into 50 ohms**
- **Continuous, triggered, gated, burst, swept, and AM/VCF sweep modes**
- **TM 5000 modular (PFG 5105) or stand-alone (PFG 5505)**
- **Non-volatile storage for 99 front-panel settings**
- **Fully programmable from front-panel and GPIB**

Price — $2,995 (U.S.) (PFG 5105)
$3,595 (U.S.) (PFG 5505)

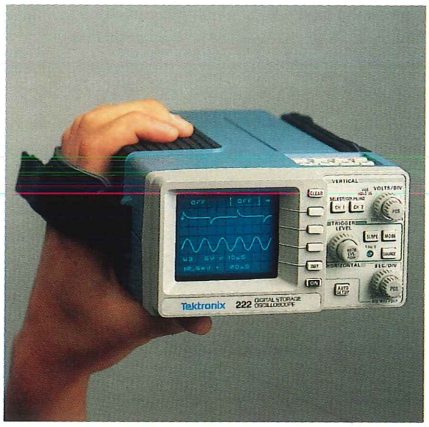
To order, or for information, call 1-800-426-2200

The Tektronix PFG 5105/5505 Programmable Pulse/Function Generator combines the advantages of a pulse generator with the versatility of a full-featured function generator. Waveform generation capabilities include pulse, double pulse, sine, triangle, square, and DC outputs. Output range is from 0.012 Hz to 12 MHz in continuous, triggered, gated, burst, swept, and AM/VCF (voltage controlled frequency) modes. A synthesizer option locks the output to an internal quartz crystal for accuracies of 0.005% (continuous mode only).

The PFG 5105/5505 is fully programmable from the front panel or via the IEEE-488 (GPIB) interface. In addition, up to 99 front-panel settings can be stored and called up either from the front panel or via GPIB. This reduces programming time and enhances stand-alone bench applications.

The PFG 5105 is compatible with Tektronix TM 5000 programmable modular test instruments and occupies three slots in any TM 5000 Mainframe. It can be combined with any of the over 50 TM 500/TM 5000 modular test instruments to form a complete stimulus and measurement system. The PFG 5505 is a stand-alone version with self-contained power and carrying case.

222 Digital Storage Oscilloscope



- 10 MHz bandwidth
- Dual 10 megasamples/second digitizers
- Automatic setup
- Storage for four control setups
- Storage for four waveforms
- 100 nanosecond glitch capture
- Auto trigger
- Floatable to 800 volts peak-to-peak
- RS-232-C output

Price — $2,350 (U.S.)

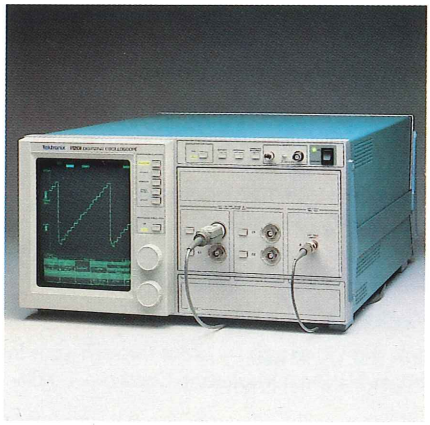
To order, or for information, call 1-800-426-2200

The Tektronix 222 Digital Storage Oscilloscope delivers dual-channel 10 MHz digital storage performance in a compact package measuring only 3.4 x 6.3 x 9.9 inches (8.6 x 15.9 x 25.2 centimeters). However, don't let this small size fool you because it has the measurement power to make accurate measurements anywhere; the on-board battery insures full portability. Battery operation and two isolated channels also allow you to safely make elevated-ground measurements.

The 222 is constructed of impact resistant materials so it can survive the rough-and-tumble world of field use. Further, the 222 satisfies MIL-T-28800D standards for altitude, vibration, and shock.

Many convenience features found in laboratory scopes are standard in the 222. For example, automatic setup allows quick acquisition of signals. Up to four control setups can be saved and recalled when needed. And four waveforms can be stored and recalled for comparison and analysis. A standard RS-232-C interface allows stored waveforms to be output to a computer for further analysis or storage.

11201 Digitizing Oscilloscope



- 400 MHz bandwidth
- 8 channel display, 4 channel acquisition
- Switchable input impedance — 50 ohms, 1 megohms
- 10-picosecond horizontal resolution, 9-bit vertical resolution
- Waveform processing and automatic pulse parameters
- Multiple 10,240-point waveform records
- External trigger capability
- Fully programmable via GPIB and RS-232-C

Price — $11,900 (U.S.)

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

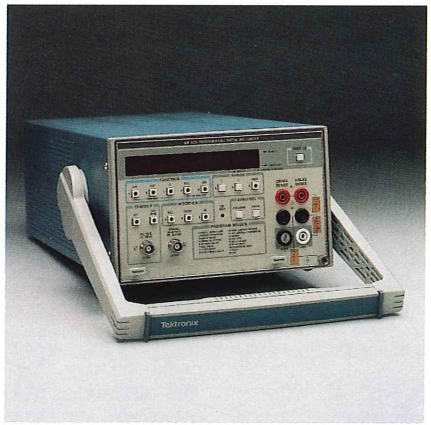
The Tektronix 11201 Digitizing Oscilloscope provides all of the functions of the Tektronix 11000 family in a monolithic package. This provides high measurement performance in an easy-to-use instrument.

Up to eight waveforms can be displayed from the four input channels. Bandwidth is 400 MHz with 9-bit vertical resolution. Input impedance is switchable between 50 ohms and 1 megohms. Horizontal measurements can be made with 10-picosecond resolution.

Built-in waveform processing capability makes measurements on the acquired signals. Up to six measurements can be displayed and continuously updated as the data changes. This lets you make adjustments and see the result in a "live" manner.

Both an IEEE-488 (GPIB) and RS-232-C interface are provided for data transfer and instrument control. Full instrument control is provided over each interface. A direct hardcopy output is provided for permanent copies of displays along with time and date stamping for archiving data.

DM 5120/5520 Programmable Digital Multimeter



- 6 1/2 digit, fully autoranging (100 nanovolts, 100 microohms, 1 nanoamp resolution)
- 1000 readings per second
- 500 measurement buffer
- DC volts, true RMS AC volts, ohms, DC amps, true RMS AC amps
- dB calculations
- Offset-compensated ohms
- Four-wire resistance measurements
- Hi/Lo/Pass limit testing
- Math functions
- TM 5000 modular (DM 5120) or stand-alone (DM 5520)
- Fully programmable from front panel and GPIB

Price — $1,795 (U.S.) (DM 5120)
$2,395 (U.S.) (DM 5520)

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

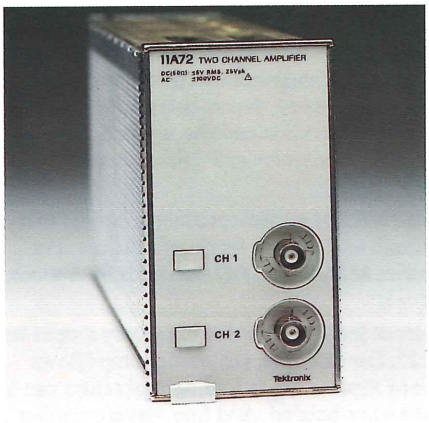
The Tektronix DM 5120/DM 5520 Programmable Digital Multimeter provides autoranging voltage, current, and resistance measurements at up to 6 1/2 digit resolution. The dynamic range of the DM 5120/5520 lets you detect low- or high-level signals with a minimum of signal conditioning. A user-programmable filter function allows the effects of external noise to be eliminated.

A fast autoranging feature permits the shortest possible test setup time and dramatically increases throughput. Just connect to the device-under-test, select the required measurement function, and let the instrument find the proper measurement range.

The DM 5120/5520 is fully programmable from the front panel or via the IEEE-488 (GPIB) interface.

The DM 5120 is compatible with Tektronix TM 5000 programmable modular test instruments and occupies three slots in any TM 5000 Mainframe. It can be combined with any of the over 50 TM 500/TM 5000 modular test instruments to form a complete stimulus and measurement system. The DM 5520 is a stand-alone version with self-contained power and carrying case.

11A72 Two-Channel Amplifier



- **1 GHz bandwidth**
- **Full-bandwidth operation for 11000-Series Oscilloscopes**
- **Dual-channel operation**
- **Wide-range, high-resolution, calibrated DC offset**
- **Fast overdrive recovery**
- **Calibrated sensitivities from 10 millivolts/division to 1 volt/division**

Price — $3,950 (U.S.)

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

The 11A72 Two-Channel Amplifier allows 11000-Series users to double the number of full-bandwidth channels available for measurements. The 11A72 provides up to 1 GHz bandwidth with 50-ohm input impedance on both input channels. Calibrated DC offset allows high-resolution measurement of large signals, even at higher sensitivity settings.

Full-bandwidth probe measurements can be made with the P6156 Passive Probe. This probe provides 10X signal attenuation while extending the 1 GHz bandwidth to the probe tip. For measurements that demand less loading, the P6204 Active Probe is available. This probe provides reduced circuit loading while providing 700 MHz bandwidth at the probe tip.

All 11000-Series amplifiers use the TEKPROBE™ interface to collect information from the probe as well as provide power for active probes. This results in more accurate measurements since all waveform information is scaled correctly and also eliminates the need for extra power cables. All probes designed for the 11000-Series have an ID push button at the probe tip to aid in locating a trace on the screen as well as to active measurement sequences from the probe tip.

SEMINARS • CLASSES • WORKSHOPS

Product Service Training Classes

Tektronix offers classes, seminars, and workshops 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.

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.

DAS9200 Digital Analysis System	Beaverton, OR	July 10-21
LV500 Logic Verifier System	Beaverton, OR	July 20-28
TM 5000 Digital Counter/Multimeter	Beaverton, OR	Sep 18-29
465B/475A Portable Oscilloscopes	Irvine, CA	Aug 7-11
49XA/P-275X Portable Spectrum Analyzers	Beaverton, OR	Jun 12-30
1240/1241 Logic Analyzers	Beaverton, OR	Sep 25-Oct 6
2215/2235/2236 Portable Oscilloscopes	Irvine, CA	Aug 14-18
2230/2232 Digital Storage Oscilloscopes	Beaverton, OR	Aug 21-Sep 1
2245/2246/2247 Portable Oscilloscopes	Irvine, CA	Aug 21-25
2430/2432/2440 Digital Storage Scopes	Beaverton, OR	Jun 12-23
2465/2467 Microprocessor-Based Scopes	Atlanta, GA	Jul 10-21
3052 Digital Spectrum Analyzer	Beaverton, OR	Aug 14-Sep 1
7612D Programmable Waveform Digitizer	Beaverton, OR	Jul 10-21
7904/7633 Lab Storage Oscilloscopes	Atlanta, GA	Sep 11-22
7912HB Programmable Digitizer	Beaverton, OR	Sep 11-22
11800 Digital Sampling Oscilloscopes	Beaverton, OR	Jul 24-28

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.

Operation, Application, and Concept Training

On-site workshops and self-study programs are available on the operation and application of Tektronix measurement products. Call Customer Training for information — 1-800-835-9433, Ext 430.

Self-Study Training Packages

Consisting of a workbook and video tape — order through your local field office or the Tektronix National Marketing Center — 1-800-426-2200.

Fundamentals of Analog Scopes	068-0270-xx	$125
Fundamentals of Digital Scopes	068-0268-xx	$125
Fundamentals of RS-232C	068-0259-xx	$125
Fundamentals of Logic Analyzers	068-0291-xx	$125
Fundamentals of GPIB	068-0260-xx	$125
Fundamentals of Probes	068-0269-xx	$125
Operating the 1230	068-0288-xx	$125
Operating the 2201	068-0290-xx	$60
Operating the 2205	068-0289-xx	$60
Operating the 2210	068-0274-xx	$125
Operating the 2213A/2215A	068-0278-xx	$125
Operating the 2220	068-0273-xx	$125
Operating the 2221	068-0272-xx	$125
Operating the 2225	068-0279-xx	$125
Operating the 2230	068-0271-xx	$125
Operating the 2235	068-0277-xx	$125
Operating the 2236	068-0276-xx	$125
Operating the 2245A/2246A	068-0275-xx	$125
Operating the 2432	068-0266-xx	$145
Operating the 2432A	068-0305-xx	$145
Operating the 2430A	068-0267-xx	$145
Operating the 2440	068-0265-xx	$145
Operating the 2445A/2465A	068-0262-xx	$145
Operating the 2445B/2465B/2467B	068-0261-xx	$145
Operating the 11301A/11302A	068-0264-xx	$145
11401/11402 Waveform Measurement	068-0302-xx	$145
11401/11402 Advanced Waveform Measurement	068-0303-xx	$145
Using the PC AS A Controller	068-0301-xx	$145

Providing a total solution for shock and vibration analysis

A new family of accelerometers expands the application of Tektronix digital storage oscilloscopes and waveform analyzers into the world of mechanical testing. Because of the fleeting nature of the impulse signals required for analysis of many environmental tests, the digital storage oscilloscope is ideal to record the information for further processing. Peak detection, averaging, integration, differentiation, comparison, correlation, smoothing, modal analysis, FFT and data storage and retrieval are all readily accomplished. These kits are ideal for use with the 2200-Series and 2400-Series Digital Storage Oscilloscopes, 2510 TestLab, 2630 Fourier Analyzer, and 11400-Series Digitizing Oscilloscopes.

The accelerometer family consists of six kits containing a transducer with internal charge amplifier, power supply, cable, and mounting hardware. These kits contain enough accessories for most general purpose measurements.

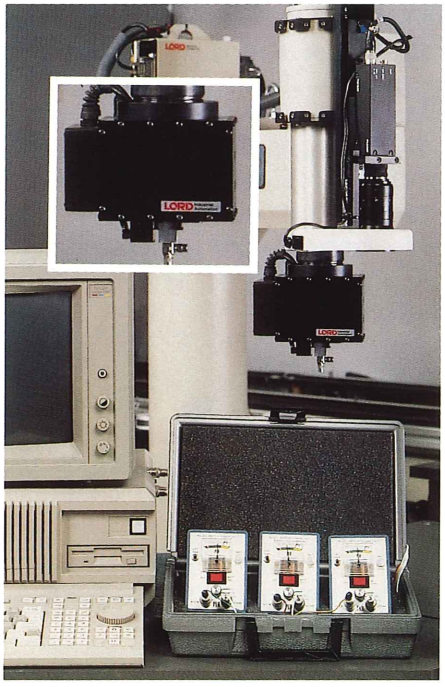


Figure 1. *TAK503 Triaxial Accelerometer mounted on the arm of a pick-and-place machine to measure acceleration/deceleration in order to calibrate unit to safely handle parts.*

The TAK500 Modally Tuned Hammer Kit provides the stimulus as well as a built-in accelerometer for measuring the force applied. Modal tuning simplifies calibration and prevents hammer resonances from affecting the test results. Striking an object with the hammer excites it with a near-constant force over a broad frequency range which can be varied with the tips and extenders supplied. The complete task of characterizing vibration modes of a structure requires impacting it with the hammer at many points and measuring the motion at one critical point (or vice versa). The impact and response signals may then be analyzed using the Tektronix 2630 Fourier Analyzer to determine mode shapes.

The TAK501 Accelerometer Kit contains a basic precision quartz transducer for the measurement of shock and vibration from 0.01g to 500g over a broad frequency range. Exceptional low-frequency response and the ability to operate in adverse environments make the TAK501 suitable for use in the field and in the laboratory for aircraft, vehicular, and industrial applications.

The TAK502 Miniature Accelerometer Kit is designed for testing smaller objects. The low mass of the miniature accelerometer prevents it from appreciably altering the characteristics of the object being evaluated. A quartz element and microcircuit amplifier permit measurement up to 500g within the frequency range of 0.7 to 20,000 Hz.

The TAK503 Triaxial Accelerometer Kit measures shock and vibration up to 500g simultaneously in three mutually perpendicular planes. Since the output of the TAK503 is three separate signals, a signal processing device such as the Tektronix 2510 Multi-Channel analyzer is the ideal approach to processing all signals from either one or two triaxial accelerometers simultaneously — up to a total of eight channels. Three precision quartz elements with internal microcircuit amplifiers in a low mass titanium cube allow measurements without distortion, even with relatively lightweight structures (see Figure 1).

The TAK50 General Purpose Accelerometer Kit is designed for low and medium frequency shock and vibration measurements for heavy machinery and structures. The measurement range is 0.001g to 50g over a frequency range of 0.7 Hz to 6000 Hz.

The TAK5 High Sensitivity Accelerometer Kit is similar to the TAK50 except that it has ten times the sensitivity. The useful frequency range is 1.5 Hz to 5000 Hz.

For information

For further information on these accelerometer kits or Tektronix instruments that are ideally suited for mechanical testing, contact your local Tektronix Field Office or sales representatives. U.S. customers can get information, prices, or place an order by calling the Tektronix National Marketing Center toll free — 1-800-426-2200. Or contact your local Tektronix Field Office or representative. And tell them you saw it in **HANDSHAKE.**

Figure 2. *Typical accelerometer kit and accessories in storage case. The TAK500 Modally Tuned Hammer Kit is shown.*

Automating digital interface testing for telecommunications

The 2410 Digital Interface Test System provides a "one-handle" test system solution for many of the tests required in telecommunications.

In order to provide high-quality signal transmission, companies providing telecommunications services must carefully monitor their system to maintain signal integrity. Or when problems develop, they must quickly pin-point the trouble source to minimize any interruption in service.

To ensure that new equipment meets or exceeds specifications, designers and manufacturers must test their equipment to the correct specifications and under conditions that simulate actual operation.

Throw away your grease pencil!

One of the common ways of making pulse-shape tests has been to physically draw a template on the screen of an oscilloscope with a grease pencil (or make a plastic template overlay for the CRT display). First, the test-pattern generator had to be correctly set up. Then, the signals had to be properly connected, the scope controls set correctly, and a proper trigger established. Finally, the signal had to be correctly positioned and the amplitude adjusted for a proper display. If all of this was done correctly, then you could begin to acquire and interpret the data. However, results were often questionable for all but the most experienced technicians, and the time to set up all of the instruments for the measurement could require hours.

Now, the 2410 Digital Interface Test System (DITS) makes these tests as simple as making a couple of signal connections and pressing a button — the 2410 does the rest. Best of all, measurements can be made on live traffic and random data. To simplify measurements, the system prompts the operator throughout the process so even a novice can make accurate measurements. And because the test standards are programmed into the system, results are repeatable and can be verified for later analysis or review.

A systems approach

The 2410 Digital Interface Test System combines state-of-the-art test equipment into a compact test system that can be easily carried to the measurement site and quickly set up for measurements. It includes the 2440 300 MHz Digital Oscilloscope with Option 11, Tektronix 2402 TekMate controller, T-Carrier Trigger unit, and test and template generation software.

Here's some of the things the 2410 brings to your digital signal interface tests:

- **Test repeatability.** Ensures that test methods are always identical and consistent with applicable standards.
- **Measurement accuracy.** Data is captured using a high-performance Tektronix digital oscilloscope. All tests conform to the applicable ANSI or CCITT standards.
- **"Live" measurements.** Measurements can be made on an active, live traffic line with no interruption, no special generators, no lost revenue, and with instant results.
- **Reduced test time.** Routine tests are reduced from hours to minutes — in many cases, to seconds.
- **Easy-to-use.** Tests are run using on-screen menus and buttons on the CRT bezel of the scope. All information and operator interface is concentrated in one central location to focus your attention on the tests being made.

- **Portable.** Forms a compact, one-handle test system that can be taken to the measurement site. Eliminates the bulk (and the cost) of the three or four pieces of additional equipment normally required.
- **Test documentation.** Test results can be logged to disk for later analysis on the 2410 or on a compatible test system such as the Tektronix PEP 300-Series Systems Controller. Or, the test results can be printed on a Tektronix HC100 Digital Plotter for a permanent test record.

What about standards?

All tests are based on ANSI T1.102-1987 or CCITT Red Book Standard, Volume Three, Recommendation G.703. Here's some of the standard tests that the 2410 can make:

Pulse shape testing. Performs tests using Tektronix-supplied software templates to ANSI DS1 (1.5 Mb) including Pub. 43802 old and new equipment specifications, DS1-C (3 Mb), DS2 (6 Mb), or DS3 (45 Mb), or CCITT 2 Mb, 8 Mb, or 34 Mb. The T-Carrier Trigger unit captures an isolated "1" for this test. Any standard template can be modified for special tests, or you can create custom templates based upon your own signals. The 2410 can log each failure with a date and time stamp so signal lines can be monitored unattended.

Pulse symmetry (balance) testing. The 2410 selects five sequential "1" pulses and then selects the center two pulses for detailed comparison. The 2410 tests power imbalance to within 0.5 dB limits for ANSI tests, or amplitude-vs-width ratio for CCITT tests.

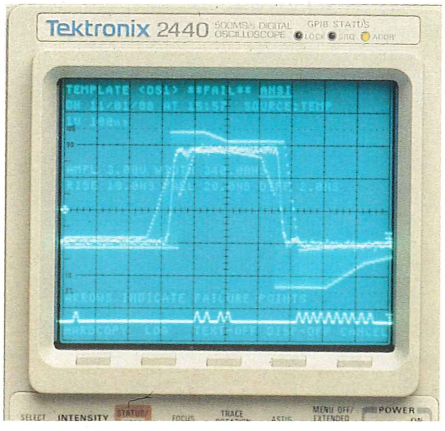


Figure 1. *Typical test screen showing a failure condition. Arrows on indicator trace at bottom of screen indicate each violation of test envelope.*

Pulse spectral power testing. The 2410 selects five sequential pulses and compares power in the second harmonic against power in the fundamental. Spectral power is tested to the respective ANSI limits for each signal type.

Multi-test looping. The 2410 can loop continuously through all of the pulse tests in an unattended mode. You can choose to log all data or only the failure data. And since logged data includes date and time stamp, you know exactly when any failures or anomalies occurred.

Generate your own test templates

A template generation program called TGEN is included with the 2410. This Microsoft Windows-based program allows you to create or modify pulse-shape templates. The 2410 recognizes any modified template as non-standard and issues a warning message if that template is used. TGEN allows you to build a template based on a live waveform or create the template point-by-point. TGEN can add absolute or relative vertical and horizontal tolerances from a working waveform, or add vertical offset to all or part of the working waveform.

A system with many uses

The difficulty and time required to set up a test system and make the required measurements has often made extensive testing cost-prohibitive. Now, the 2410 eliminates many of those barriers, allowing you to expand your test plan for improved performance and system integrity. Some of the ways you might use the 2410 include:

System maintenance. Most maintenance engineers know they should routinely make industry standard shape tests. However, conventional methods of making these pulse-shape tests using manual systems are too time-consuming for day-to-day testing. Also for lower transmission rates, many digital carrier personnel believe they can rely on the experience of their system engineers to diagnose problems that appear at the digital cross-connect points.

The expanding use of higher rates requires more specialized expertise than is always available. In this case, an automated digital interface test system can provide ready answers and fill the growing gap between demand and supply for experienced system engineers.

Testing new systems. When a digital carrier commissions a new data communications exchange, company policy often requires maintenance engineers to check every line for pulse shape. Using manual methods, this can be time consuming and expensive. The 2410 not only simplifies these tests, but also provides documentation for a permanent record of system performance. These complex tests can be reduced from weeks or months to a matter of days.

System manufacturing test and design. Manufacturers of telecommunications equipment need to test their system to the applicable standards and provide assurance to the end-user that the tests have been made and that the system performs to the applicable standards. The 2410 provides a convenient method of testing the system as well as providing documentation to verify system performance.

For more information

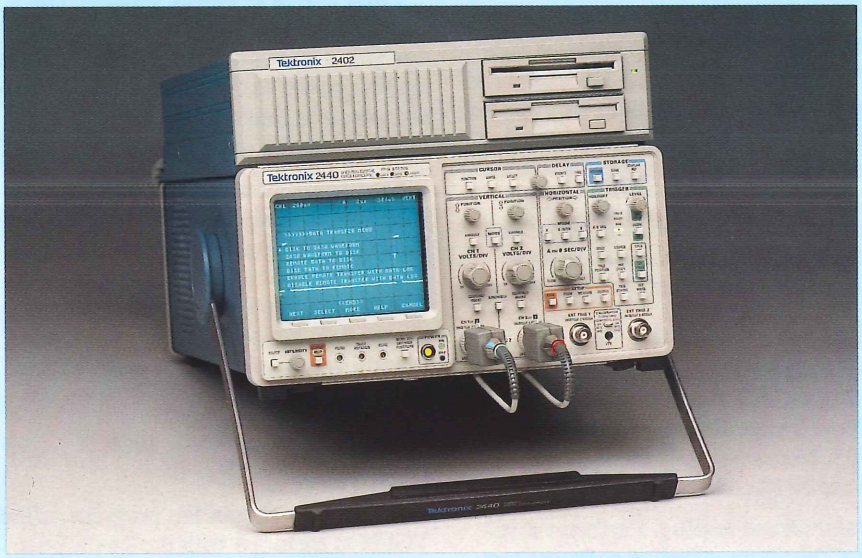
We've only given an overview of the tests that must be made to verify signal integrity in a telecommunications system. If you would like more information on the 2410 or a demonstration of its capabilities, contact your local Tektronix Field Office or sales representative. U.S. customers can call the Tektronix National Marketing Center toll free — 1-800-426-2200 — to place an order or for information. And tell them **HANDSHAKE** sent you.

Literature corner

The following literature provides additional information on the topics and instruments discussed in this article. Copies are available from your local Tektronix Field Office or sales representative:

- **Quickly and Accurately Verifying T-Carrier Pulse Quality — 37W-6989-1**
- **Verifying DSX Signals to Industry Standards with the 2410 — 37W-7145.**

Putting "portability" into portable measurements



The 2402 TekMate attaches to a Tektronix 2400-Series digital oscilloscope to turn it into a portable acquisition, processing, and display system.

The Tektronix 2402 TekMate brings a new dimension to portable measurements — on-board processing previously available only with an external controller. The 2402 extends the extensive testing, waveform storage, and analysis capabilities of the Tektronix 2400-Series digital oscilloscopes by easily creating templates for pass/fail waveform testing, storing over 300 waveforms on a single disk, and performing complex waveform analyses such as the FFT. Addition of the 2402 to a 2440, 2432A, or 2430A Digital Oscilloscope produces a compact test system that can be easily taken to the measurement site.

The 2402 attaches directly to the 2400-Series digital scope. It adds only three inches (7.9 cm) height and 10 pounds (4.6 kg) to the basic scope package. The convenient form-factor and single-handle carrying case allow you to take extensive measurement and waveform processing capabilities to areas previously not possible.

An integrated package

The 2402 isn't just a controller package "tacked" on as an after thought. Instead, it forms a completely integrated package with the scope. Menus and test results are displayed on the scope screen. Through the control buttons provided on the bezel of 2400-Series digital scopes, you can access all of the functions of the 2402 TekMate, including entering or modifying the program. And since all interface connections between the scope and TekMate are already made, you don't have to worry about getting everything properly connected when you arrive at the site and want to start acquiring data.

MS-DOS compatibility

An important consideration in choosing a test system is its software compatibility to existing systems and controllers. TekMate is based upon the familiar IBM PC architecture and is compatible with MS-DOS based programs. In addition, it provides two full or three half IBM PC-compatible expansion slots so you can choose from the many available cards to expand your capabilities even further.

One of the biggest advantages of all this compatibility is the ability to interchange both data and programs with IBM-compatible test systems such as the Tektronix PEP 300-Series Systems Controllers. Data gathered on-site with the TekMate system can be transferred to a lab-based system via disk or modem (using either the RS-232C or GPIB interface) for further analysis. In addition, test programs can be developed on a PEP 300-Series Systems Controller and then transferred and executed by the 2402.

Test and measurement software

Here's a summary of the software packages currently available to support the 2402 TekMate:

- **DSO Utilities Applications Software.** Includes routines to store and retrieve waveforms and set-ups to/from disks, log data at user-determined intervals, generate envelopes for pass/fail comparison, time/date stamp files, and perform advanced math functions.
- **DSO Program Development Software.** Provides a library of subroutines to aid in the development of custom programs. Also includes Microsoft QuickC and QuickBASIC programming languages.
- **EZ-Test PC Test Program Generator.** A complete test program generation software to help you develop custom programs. Test programs can run in automatic or semi-automatic mode.

For more information

For information on the 2402 or any of the software or instruments that it's compatible with, contact your local Tektronix Field Office or sales representative. U.S. customers can call the Tektronix National Marketing Center toll free to order or for information — 1-800-426-2200.

The ultimate portable digital oscilloscope

The 500 Megasamples/second sampling rate and 300 MHz bandwidth of the 2440 Digital Oscilloscope combine to offer the highest performance in a portable package.

The Tektronix 2440 Digital Oscilloscope packs a lot of power into the familiar portable package that has become the standard of the industry for portable measurements — 300 MHz bandwidth, 8-bit vertical resolution, 500 megasamples/second sample rate, automatic measurements, simultaneous dual-channel acquisition, and more. This combination of high resolution and high sampling rate provides more horizontal and vertical waveform detail. The result is the ability to capture very fast single-shot events with significantly improved accuracy.

Automatic measurements for greater accuracy

The high-performance 2440 builds upon, but also enhances, all the popular built-in automation features pioneered by the other 2400-Series digital oscilloscopes — features which users have come to expect as the standard for portable measurements. Some of the 2440 features include:

- **Automatic set up.** Even unknown signals can be captured and displayed on the 2440 with the push of a single front-panel button or from the probe tip. Controls are automatically configured to display the selected channel in the selected mode.
- **Automatic measurements.** Automatically measures, displays, and updates up to four parameters from one or more displayed waveforms. A single "snapshot" of up to 20 waveform parameters, including amplitude, frequency, risetime, falltime, pulse width, and propagation delay, can be made simultaneously.
- **Automatic sequencing.** Test programs can be designed, stored, and run, with or without a controller. Up to 200 front-panel setups, user prompts, test procedures, and associated control and I/O actions can be stored in up to 40 named test sequences.
- **Automatic pass/fail testing.** Built-in pass/fail decision making compares incoming waveforms to a user-definable waveform envelope. Known good waveform templates can be generated or downloaded into the scope and automatically compared to a live waveform. Violations of the template (signals that are outside the reference limits) are captured, time-stamped, and horizontally centered on screen for easy examination.

The perfect system component

The 2440 contains the features that make it the most advanced digital oscilloscope for completely automated, unattended measurements. In addition, it's designed to take advantage of the added power of an external controller for more complex measurements. All controls are GPIB-programmable. With a simple command, the scope transmits waveform data, measurement results, and scope settings over the bus.

Two features increase throughput and reduce bus traffic when used as part of a system — the ability to rapidly transfer information to other devices and the ability to transfer selected measurement results and selected portions of waveforms.

With test and measurement software available from Tektronix, you can easily put together your own 2440-based test system using the Tektronix PEP 300-Series Systems Controller (or other IBM PC-compatible computer) or the Tektronix 2402 TekMate (see accompanying article on **Putting "portability" into portable measurements** for information on the 2402 TekMate). For test and measurement software available from Tektronix, refer to the current Tektronix Products Catalog or request a Tekware Test and Measurement Software catalog on the **HANDSHAKE** reply card.

For more information

For information on the 2440, contact your local Tektronix Field Office or sales representative. U.S. customers can call the Tektronix National Marketing Center toll free to order or for information — 1-800-426-2200.

HANDSHAKE article index for Volume 13

For copies of any of these back issues, please use the **HANDSHAKE** *reply card included in this issue.*

Vol 13, No 1 — Spring 1988
TOPIC — Tektronix Goes to School

Choosing equipment for the classroom — the instructor's dilemma ..... page 4
Tektronix goes to school ..... page 6
A total educational package ..... page 8
Help for your basic electronics curriculum ..... page 9
A close-up look at the Classroom Series ..... page 10
Teaching automatic test equipment concepts at Purdue University ..... page 12
Logic analyzers in education ..... page 15
The Engineering Bench Series — a better way to purchase TM 500/TM 5000 instruments ..... page 17
Q&A ..... page 18
Electrical safety ..... page 19
Third-party safety certification ..... page 21
HANDSHAKE article index for Volume 13 ..... page 22
Climbing the learning curve faster with operation training .. page 23
Classes and Seminars ..... page 24

Vol 13, No 2 — Summer 1988
TOPIC — A New World of Dynamic A/D Characterization

Q&A ..... page 2
Asynchronous dynamic testing of A/D converters ..... page 4
Dynamic characterization of A/D converters ..... page 8
Isolating failures on multi-pin devices ..... page 12
Testing high-power devices ..... page 15
Software makes device testing easier ..... page 16
Wind tunnel automation ..... page 17
Making the remote connection ..... page 19
Warranty-Plus: On-site service for Tektronix Test Systems page 22
Classes and Seminars ..... page 24

Vol 13, No 3 — Fall 1988
TOPIC — A New Dimension in Signal Analysis

Q&A ..... page 2
Low-frequency analysis with the Tektronix 2630 Fourier Analyzer ..... page 4
Making test procedure generation quick and EZ ..... page 9
A new way to buy direct from Tek ..... page 14
High-frequency measurement of optical signals ..... page 15
Analog oscilloscopes gain new features ..... page 16
What is a microchannel plate? ..... page 17
The best of both worlds ..... page 18
Small size, big DSO performance ..... page 19
The RTD 710A Waveform Digitizer — new capabilities, new performance, new systems ..... page 20
Automated impedance characterization and control ..... page 22
What is 7854 TAMS? ..... page 24
Card-modular test systems — the TSI family evolves ..... page 26
Automated manufacturing test systems for resource-limited companies ..... page 29
Classes and Seminars ..... page 32

Vol 13, No 4 — Winter 1988/89
TOPIC — High-precision picosecond measurements

Introducing the 11800 family of digital sampling oscilloscopes ..... page 4
Digital time base provides unmatched time resolution ..... page 6
What is an LSB? ..... page 10
Q&A ..... page 11
Removing fixturing delays from propagation delay measurements ..... page 12
TDR refresher ..... page 13
Hardware makes timing measurements faster ..... page 16
Basic sampling concepts ..... page 18
Glossary of sampling terms ..... page 20
Making the most of available space ..... page 23
A new method of viewing and extracting information from digital signals ..... page 24
A practical approach to optical waveform analysis ..... page 26
Multiplying your waveform acquisition options ..... page 30
Another way to output your data ..... page 31
Classes and Seminars ..... page 32

Establishing the basis for differential TDR measurements with the 11800-Series Oscilloscopes

Roy Lewallen
Electrical Engineer
High-Frequency Component Development Group
Tektronix, Inc.

Introduction of the 11800-Series Digital Sampling Oscilloscopes (see **Introducing the 11800 family of digital sampling oscilloscopes** in the Winter 1988/89 HANDSHAKE) made possible a new measurement technique — direct measurement of impedances in differential systems. However, to take full advantage of this new technique we must establish the meaning of some terms commonly used for these measurements.

There are numerous ways to characterize a differential line. Some typical conventions are described by the terms characteristic impedance, differential impedance, and common-mode impedance. However, since a difference occasionally arises in the definition of these terms, we've chosen to use two more well-defined terms for measurements with the 11800-Series — odd-mode impedance and even-mode impedance. The odd-mode impedance of a differential line is one-half of the characteristic impedance or differential impedance; even-mode impedance is twice the common-mode impedance.

The impedance between the two conductors of a differential line, and between each conductor and ground, can be represented by a three-resistor model. Either a pi or tee model can be used since both models have identical terminal characteristics (see Figure 1). Using these models, the difference between these terms can be explained. To simplify this discussion, it's assumed that the systems described here are balanced with respect to ground.

Characteristic impedance (Z_{char}) is a term commonly used by cable manufacturers and users. For this application, the characteristic impedance is defined as the impedance between the two conductors when they are isolated from ground. From the pi and tee models of Figure 1 you can see that isolating the conductors from ground causes R_b to disappear from the pi model and R_2 to disappear from the tee model. The equivalent pi and tee models when the conductors are isolated from ground are shown by the shaded components in Figure 1. Equivalent impedance is represented by R_{ai} and R_{1i} which replace R_a and R_1 respectively.

With these models you can see that the characteristic impedance = R_{ai} (pi model) or = $2R_{1i}$ (tee model). Unfortunately, the term characteristic impedance has a different definition when used in the design of transmission line couplers (and perhaps elsewhere).

Differential impedance (Z_{diff}) is defined as the impedance measured between the two conductors (see Figure 2). With these models, you can see that the differential impedance = $R_a \| (2R_b)$ (pi model) or = $2R_1$ (tee model). In the special case where the conductors are isolated from ground, differential impedance is equal to the characteristic impedance.

Common-mode impedance (Z_{cm}) is defined as the impedance of two conductors relative to ground when the conductors are connected together. Figure 3 shows the equivalent pi and tee models for common-mode impedance. With these models, you can see that common-mode impedance = $R_b/2$ (pi model) or = $R_1/2 + R2$ (tee model). However, you must be careful when using the terms differential impedance and common-mode impedance, since the terms are sometimes used differently than described here.

Odd-mode impedance (Z_{om}) and even-mode impedance (Z_{em}) are terms used frequently to describe transmission line structures (particularly in microwave applications). Odd-mode impedance is the impedance of either conductor with respect to ground when the pair is driven differentially. Figure 4 (top) shows the equivalent pi and tee models for calculating odd-mode impedance. (V denotes a virtual ground that is created in the circuit when the conductors are driven differentially.) Using these models, you can calculate that odd-mode impedance = $(R_a/2) \| R_b$ (pi

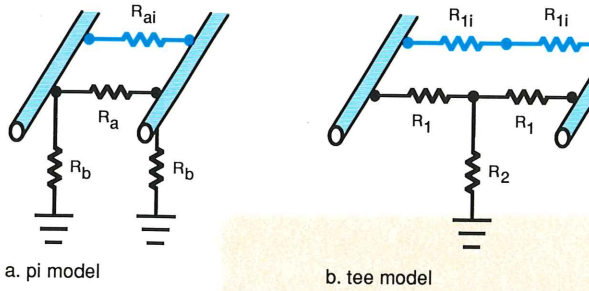


Figure 1. *Pi and tee models of impedance between the conductors of a differential line as well as to ground. Shaded components represent the equivalent pi and tee models when the conductors are isolated from ground.*

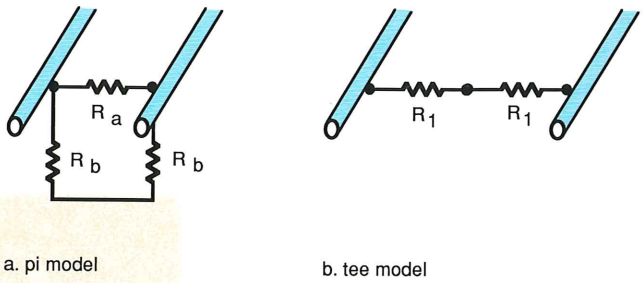


Figure 2. *Pi and tee models for measuring the differential impedance.*

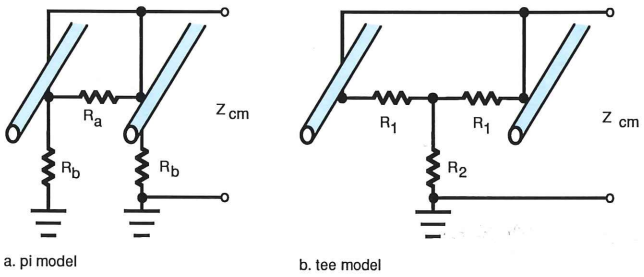


Figure 3. *Pi and tee models for measuring common-mode impedance.*

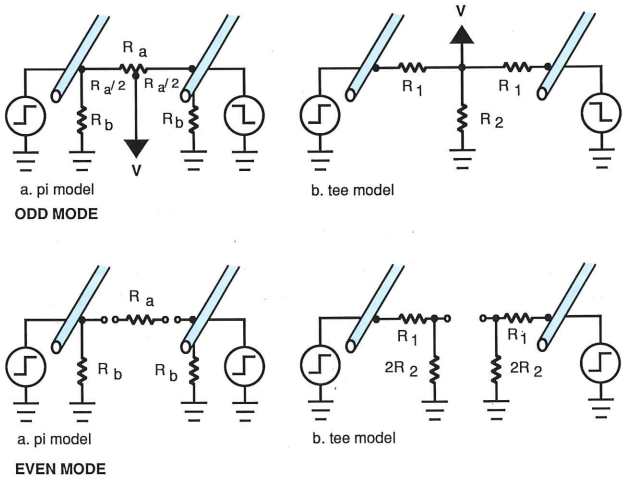


Figure 4. *Pi and tee models for odd-mode impedance (top) and even-mode impedance (bottom).*

model) or = R_1 (tee model).

Even-mode impedance is the impedance of either conductor when the pair is driven with identical, same-polarity signals. Figure 5 (bottom) shows the equivalent pi and tee models for even-mode impedance. (The virtual open circuits are created where there is no current flowing between two nodes of the circuit.) Using these models you can see that the even-mode impedance = R_b (pi model) or = R_1+2R_2 (tee model).

Comparing Figure 4 with Figures 2 and 3, you can see that odd-mode impedance is one-half the differential impedance and even-mode impedance is twice the common-mode impedance. When the differential line is isolated from ground, odd-mode impedance is one-half the characteristic impedance.

The 11800-Series ohms cursors always display the odd-mode impedance when driving the two conductors with two TDR step generators if the step generators are of opposite polarity; even-mode impedance is displayed if the step generators are the same polarity. This relationship is true whether observing only one TDR waveform or when adding (for same-polarity excitation) or subtracting (for opposite-polarity excitation) two TDR waveforms.

You can obtain common-mode impedance by measuring same-polarity excitation and then dividing the ohms readout by two. Alternatively, you can connect the two conductors together and drive the system with a single step generator to obtain the common-mode impedance. To obtain differential impedance or characteristic impedance of a balanced differential line, you must drive the line differentially and then multiply the ohms readout by two. Of course, the differential line must also be isolated from ground to measure the characteristic impedance. At present the only method available to measure the differential impedance or characteristic impedance directly is to perform a waveform calculation (defining a waveform as 100 * (1 + (M1 – M2) / 0.5) / (1 – (M1 – M2) / 0.5); where M1 and M2 are the TDR waveforms and the 0.5 results from assuming 250 millivolt incident steps.)

Want more information?

The11800-Series Digital Sampling Oscilloscopes have the unique ability to directly measure impedance in balanced differential systems. Several application notes are available that describe how to make differential TDR measurements with the 11800-Series; ask your local Tektronix Field Office or sales representative. For more information or a demonstration, contact your local Tektronix Field Office or sales representative. U.S. customers can call the Tektronix National Marketing Center toll free for prices or information — 1-800-426-2200.

HANDSHAKE
Group 157 (94-150)
Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077
Address Correction Requested

49W-7445