For Industrial Maintenance and Consumer Servicing Professionals

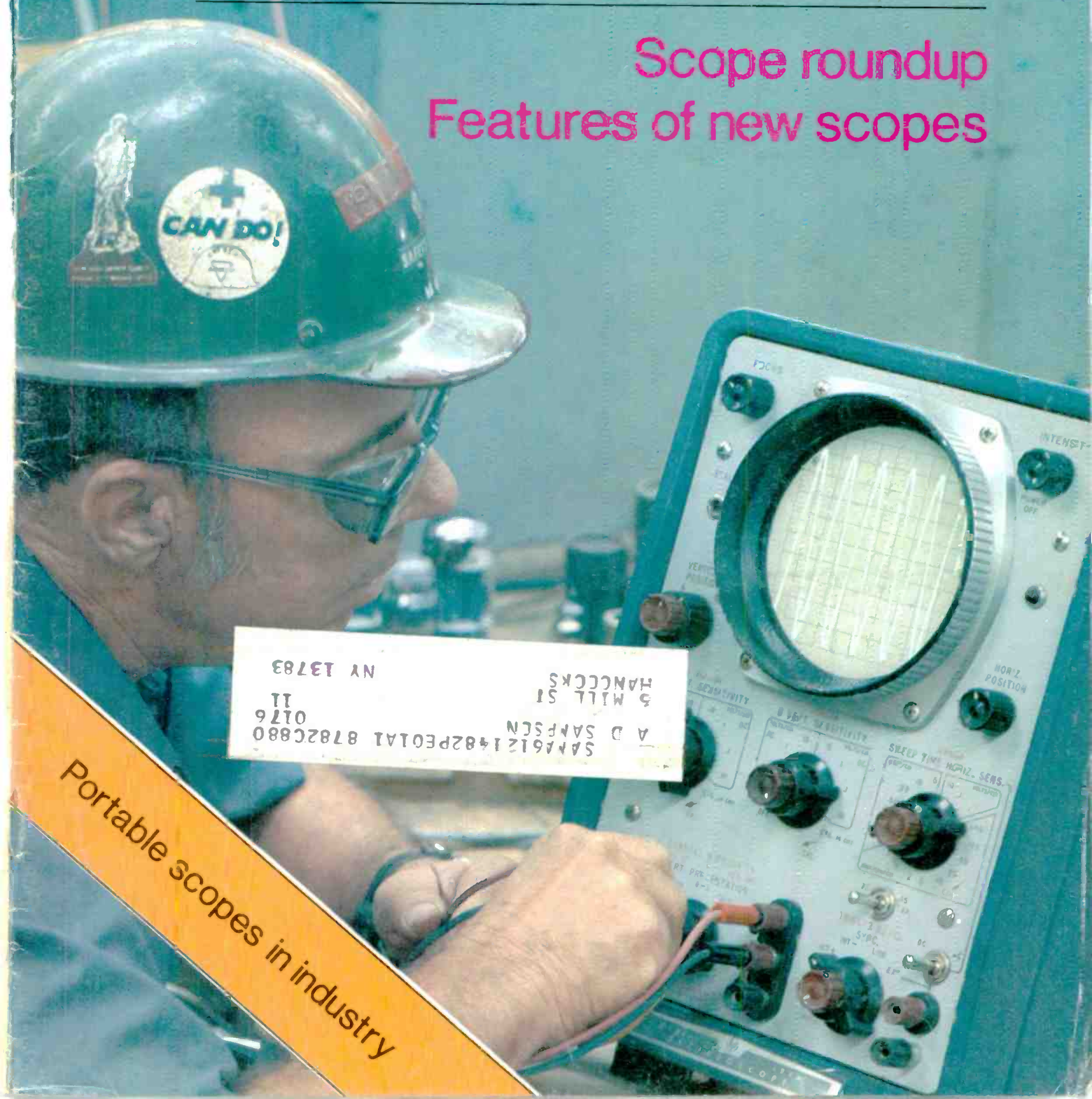
October, 1980 □ $2.25

Electronic Servicing

Annual scope issue

Scope roundup

Features of new scopes



Portable scopes in industry

Electronic Servicing

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Next month in

Electronic Servicing

Industrial Maintenance

- Soldering and desoldering roundup
- Fast soldering techniques

Consumer Servicing

- Practical scope tips, Part 2
- Servicing audio cassette tape recorders

For industrial maintenance and consumer servicing professionals

Electronic Servicing®

October, 1980 □
Volume 30, No. 10

Industrial MRO

Consumer Servicing

Industrial MRO & Consumer Servicing

Departments

About the cover

Rayford Martin operates a Hewlett-Packard 122A scope as he troubleshoots a P.A. amplifier in the electronic maintenance department of the Midwestern Steel Division, ARMCO Inc., Kansas City, MO. For more information on scopes, see *New scope features*, page 20.

Photograph courtesy of Midwestern Steel Division, ARMCO, Inc.

EDS committee chairmen appointed

The 1981 Electronic Distribution Show committee roster has been announced by Lewis H. Shuler, Dixie Electronics, president of the Electronic Industry Show Corporation. Shuler will be chairman of the executive committee, which includes three Show Corporation officers: Timothy Coakley, Coakley Boyd and Abbet, vice president; Frank Vendely, Mallory Distributor Products, secretary; and Jack Kirschbaum, Cole Flex, treasurer. Kirschbaum will head the finance committee. Other members of the committee include Eugene B. Chaiken, Almo Electronics; William G. Little, Quam-Nichols; E. Jess Spoonts, J.Y. Schoonmaker Company; and Earl H. Twietmeyer, United Radio Supply. Coakley, educational chairman, will serve as Show Corporation advisor on marketing seminars, and will be the official liaison with the National Electronic Distributors Association, which is responsible this year for distributor education activities at the Show. Welcoming activities, newcomer orientation, and ladies program arrangements will be organized by Twietmeyer, chairman of the Hospitality Committee.

As Publicity Chairman, Spoonts will work closely with Show Corporation's public relations council, Market Communication Associates, on activities to stimulate Show attendance and encourage exhibitor participation. Spoonts will head a special manufacturer-distributor-rep committee with Lindholm and Vendely, which will advise on Show promotions proposed by the three sponsoring organizations of the Show Corporation.

Space assignments, the show floor plan, housing and badging procedures will all be coordinated by the Arrangements and Registration chairman, Robert R. Daugherty, Swieco.

The marketing division vice presidents will focus on specific programs to stimulate exhibitor recruitment and distributor participation in the 1981 Show. These marketing vice presidents, and their respective committees are: Chaiken, consumer products vice president, assisted by Show Corporation past-president James R. Kaplan, Cornell-Dubilier Electronics, and Shuler; and B.R. Lindholm, general line vice president, Melvin Electronics; assisted by Thomas V. Surber, Howard W. Sams & Company; Earl H. Twietmeyer II, United Radio Supply; and Donald W. Yates, Radio Distributing Company.

For further information on EDS '81, contact Electronic Industry Show Corporation, 222 S. Riverside Plaza, Chicago, IL 60606. Telephone: (312) 648-1140.

Thordarson invites technician comments

Thordarson Meissner has established a review board to act on advice received from service technicians. A postage-free reply card will be packed with each Thordarson flyback and yoke. The card lists several questions about installation, replacements, and comments about the product. Each month the review board will meet to review the cards received and take appropriate action.

Technicians who purchased Thordarson products prior to this announcement may obtain cards by contacting John Evans, marketing program manager, Thordarson Meissner, Electronic Center, Mt. Carmel, IL 62863.

14th NEPCON WEST expanded for 1981

NEPCON WEST '81, will be held February 24-26, 1981, at the Anaheim Convention Center, Anaheim, CA.

Plans for an expanded exhibition in 1981 are in full swing, according to Philip P. Ullo, executive vice president of the Kiver Organization, which presents the annual event. Ullo indicated that nearly 140,000 sq. ft. of display space is being readied to accommodate exhibitor demand, to make NEPCON WEST '81 larger than any previous show. A comprehensive conference program to parallel this expansion also is under development, he said.

NEPCON WEST '81 is open to all persons active in the manufacture and test of printed circuits, multilayers, microelectronic circuitry, semiconductors and other devices.

For more information, contact: Industrial and Scientific Conference Management, 222 West Adams St., Chicago, IL 60606. Telephone: (312) 263-4866.

1981 Sound Conference planned

Preliminary arrangements for the 1981 Sound and Communications Conference, to be held May 5-7 in conjunction with the 1981 Electronic Distribution Show in Atlanta, have been announced by William Little, Quam-Nichols Company, vice president of the Show Corporation sound marketing division.

The Conference, the second of its kind, is expected to follow the same format as the first Conference held last May in Las Vegas. One change for 1981 is the presence of a new co-sponsor (with the Show Corporation) for the Conference, the National Sound and Communications Association, formed as an outgrowth of last year's meetings. The 1980 co-sponsors, Electronic Representatives Association and Sound Publishing Company, remain involved as endorsers and planners of the 1981 event.

For more information about the Sound Conference, contact: David L. Fisher, 222 S. Riverside Plaza, Suite 1606, Chicago, IL 60606; Telephone (312) 648-1140. □

people in the news

R.J. Hancock (left), president, Intertec Publishing Corp., with George H. Seferovich, former Intertec president.

Hancock named president of Intertec Publishing

The appointment of **R.J. Hancock** as president of Intertec Publishing Corporation, publishers of **Electronic Servicing, Broadcast Engineering, Video Systems and Radio y Televison** magazines, among others, was announced in August by David S. Davidson, director, operations, consumer services, publishing and home products for ITT.

Hancock joined Intertec in 1960 and had been executive vice president since 1979. He succeeds **George H. Seferovich**, who retired after 32 years with the company.

Previously, Hancock was publisher of Intertec's Landscaping Group of magazines and advertising sales manager for various Intertec publications, including **Broadcast Engineering**.

He received a bachelor of science degree in advertising from Oklahoma State University.

Seferovich's positions with Intertec had included that of editorial director of **Broadcast Engineering** and **Electronic Servicing** magazines. He created several other publications, including **Video Systems** magazine.

Kevin Kious has been named managing editor for Intertec Publishing Corporation's Electronic Group magazines, **Electronic Servicing, Broadcast Engineering, Radio y Television and Video Systems**, it was announced in July by George Laughead, group publisher.

A graduate of the University of Kansas School of Journalism, where he was editor of the 18,000-circulation daily student newspaper, Kious most recently was news editor of *Boxoffice*, a national weekly business publication for the motion picture industry.

Previously, he worked for the

Oakland Press, a daily newspaper in Pontiac, MI.

John Obst has been named editorial director for Howard W. Sams & Co., Inc. Obst previously was manager of acquisitions for Bobbs-Merrill Educational Publishing.

F. Craig Huston has been appointed vice president, network systems marketing, GTE communications products. He had been vice president-international relations for the group since 1978.

David A. Biddle, has been named head of product planning and research at TRW RF Semiconductors. He was previously marketing manager for Powertec.

L. Wayne Oliver, vice president and director, marketing and business development for ITT Cannon Electric, North America, has been elected president of this division of ITT. He will replace **James H. Anderson** who has been promoted to assistant group general manager.

Also at ITT Canon, **Robert J. Trivison** has been promoted from vice president to senior vice president and director of operations.

John W. Markland, manager of trade shows for Magnavox Consumer Electronics, has retired after 44 years with the company, the longest continuous employee service record in Magnavox history.

Also at Magnavox, **Ronald R. Belli** has been named vice president, sales and marketing, audio division. He has been in the consumer electronics field since 1970.

Jerry L. Earl has been appointed regional manager for the Midwest region, sales management, Leader Instruments. He was previously product specialist for test systems at GenRad.

Joseph H. Scott, Jr., has been named director of General Instrument's corporate research and development laboratory. He was director, integrated circuit technology, RCA.

Kenneth Piggot has joined B&K-Precision/Dynascan as regional sales engineer. Previously, Piggot was a field sales specialist for Gould. □

Reports from the test lab

Each report about an item of electronic test equipment is based on examination and operation of the device in the **ELECTRONIC SERVICING** laboratory. Personal observations about the performance, and details of new and useful features are spotlighted along with tips about using the equipment for best results.

By Carl Babcoke, CET

The Hickok model 240 video generator (Figure 1) has several functions in addition to the usual color/bar functions. A slide switch (Figure 2) selects any of 11 patterns that are available as video or a video-modulated TV-channel RF carrier (adjustable to channel 2, 3 or 4). A second function of the on/off switch selects RF or video. The signal exits at the RF or video output jacks below the sliding pattern-selector switch. Two variable controls allow adjustment of RF-carrier and chroma levels.

Another output jack provides vertical and horizontal sync pulses for jitter-free locking of these video waveforms.

Unusual patterns

In addition to the 10 color bars, vertical lines, horizontal lines, dots and crosshatch patterns, model 240 has six less common patterns (Figure 3). The three color bars are the third, sixth and ninth of the usual keyed-rainbow pattern. They are useful for vector displays and allow faster chroma evaluations. The single cross is exactly in the center of the picture where it provides a standard for rapid centering.

Perhaps the most unusual pattern is a 10-step change of brightness that appears on the picture tube as 10 vertical bars ranging from white to black. On a scope screen, the 10 steps resemble a staircase. This pattern is excellent for testing gray-scale tracking of raster b&w tint and for identifying amplitude nonlinearity in the TV receiver.

Other features

Model 240 measures 5-7/8 x 3-3/8 x 1-3/4 inches and weighs 13 ounces. A form-fitting plastic cover (Figure 4) encloses the test cables and provides protection against damage. The size and weight make the unit suitable for use during service calls. A transformer-type ac adapter is furnished with the generator, or it can be operated (15

Figure 1 The Hickok model 240 video generator can be held in the hand and the sliding knob of the pattern-selector switch can be moved by the thumb. Both RF and video signals are available from this crystal-controlled video/crosshatch generator.

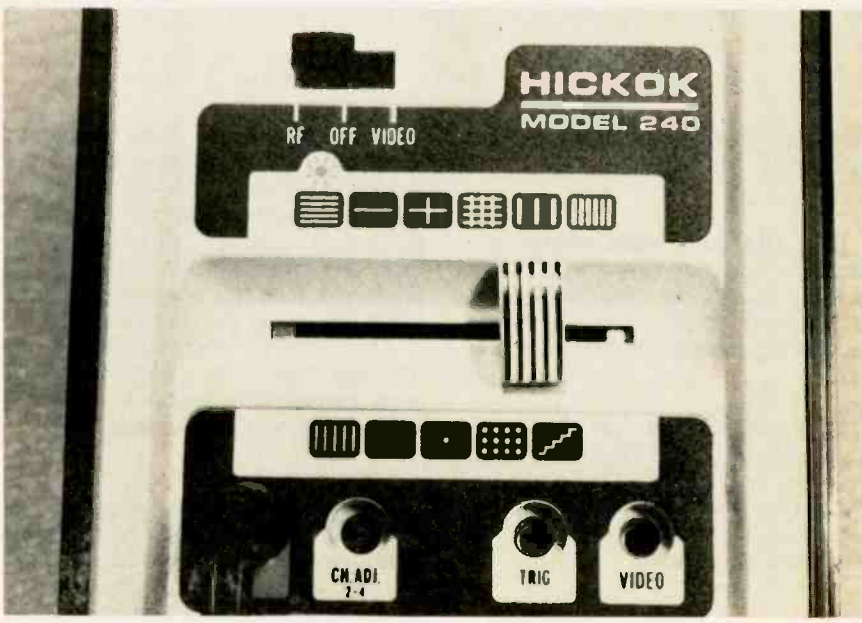


Figure 2 A small reproduction of the pattern marks each detented position of the sliding pattern switch. An LED mounted between the two variable controls lights up on the horizontal-bars position to indicate battery condition. Three jacks and a trimmer are at the bottom. The jacks are for RF, trigger and video outputs; the trimmer adjusts the precise channel carrier frequency.

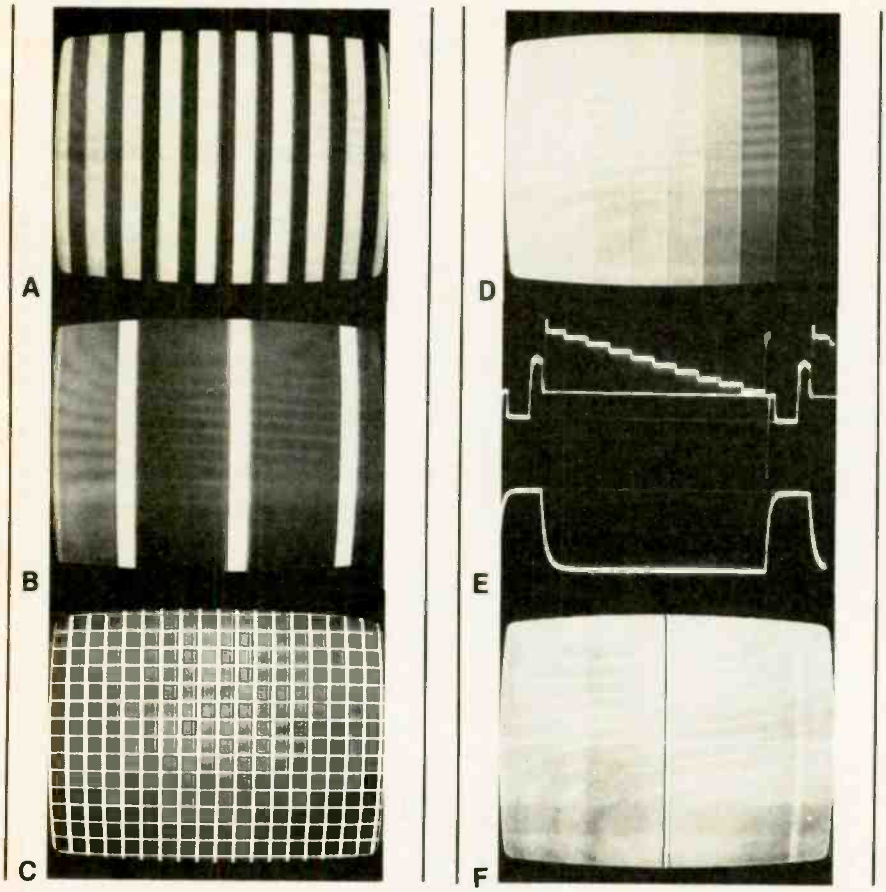


Figure 3 These photographs illustrate several of the patterns: (A) Standard 10-bar gated rainbow pattern has black bars between the color bars; (B) Some color tests can be finished more quickly by observing only the third, sixth and ninth color bars; (C) The crosshatch pattern has squares of equal height and width, making height and linearity adjustments easier; (D) Ten steps of brightness can reveal nonlinearities in videocassette recorders or TV video amplifiers; (E) When viewed on a scope, the 10-step bar pattern has a staircase appearance; and (F) The single cross is useful for picture centering.
Note: Any dim horizontal bars in the pictures should be ignored.

Figure 4 A cover, two output cables, instruction book and the ac adapter come with each Hickok model 240 video generator.

hours for video or 30 hours with RF output) from two alkaline 9V batteries.

Video signals are the standard 1VPP negative-going-sync waveform that is standard for videocassettes and TV broadcasting. Of course, the video can be injected into appropriate receiver video stages for signal-injection tests.

Chroma and timing oscillators are crystal controlled for excellent stability. The channel oscillator is adjustable to permit interference-free operation in all localities. Select a channel without a TV signal and adjust the trimmer capacitor for a sharp stable pattern on the TV undergoing tests.

Comments

All functions and patterns operates exactly as intended Model 240 was selected to supply the generator signal for the **Electronic Servicing** RCA CTC99 series. Its operation was satisfactory. However, a temporary problem occurred from a peculiarity of the RCA tuning system and the 240 adjustable RF-carrier frequency. About once per second, the RCA picture jumped rapidly to the left when tuned to the generator frequency of channel 2. Previously, the generator had exhibited perfect stability when connected to another television, so the generator was not suspected of having a defect.

The RCA CTC99 has a phase-locked loop (PLL) tuner-control system that accommodates cable signals (or other non-FCC frequencies) by adding AFC to override the crystal-controlled tuning. Perhaps the picture jump was caused by such hunting. A careful adjustment of the generator trimmer provided a picture of good stability. This is not a defect of the Hickok 240, but it is mentioned because the same problem can occur with other brands of PLL tuner controls.

After the channel frequency was adjusted, the sample Hickok model 240 video generator operated flawlessly. It is recommended for use in TV servicing and video testing.

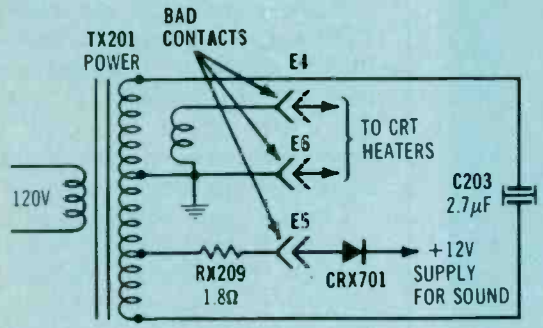
The price of the Hickok model 240 video generator is $159. □

Circle (39) on Reply Card

symcure

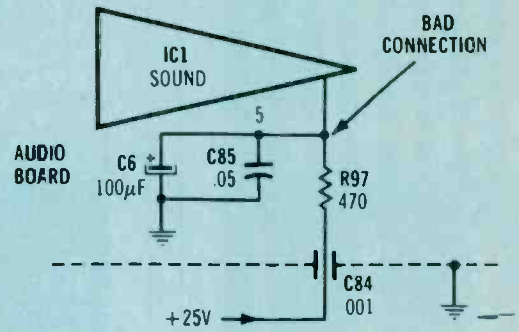
Symptoms and cures compiled from field reports of recurring troubles

Chassis—Zenith 19GB1Z
PHOTOFACT—1692-2



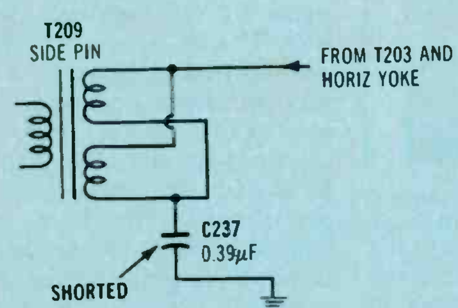
Symptom—Audio is intermittent and/or CRT heater does not light
Cure—Check and repair bad edge-connector contacts at terminals E4 and E5

Chassis—Zenith 4B25C19
PHOTOFACT—1166-3



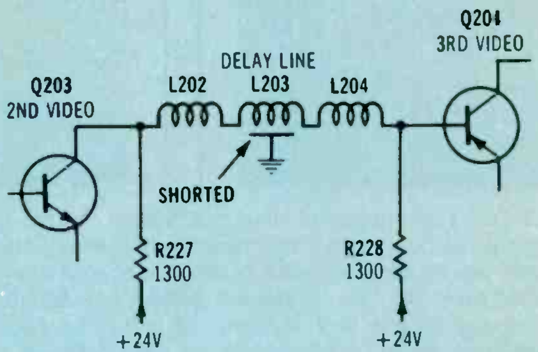
Symptom—Intermittent low sound volume
Cure—Check and repair poor soldering at R97 on audio board

Chassis—Zenith 25EC58
PHOTOFACT—1370-2



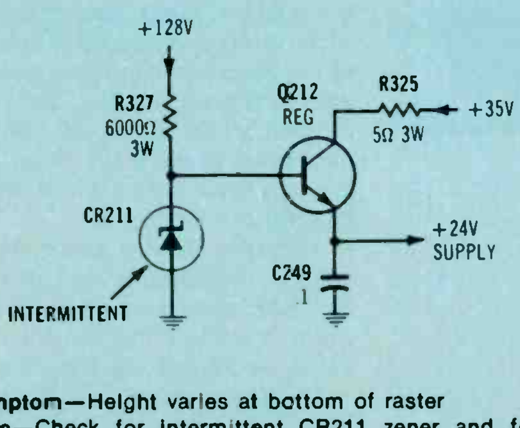
Symptom—Tripped breaker; when reset, loud hum is heard for five seconds before breaker trips again
Cure—Check yoke capacitor C237, and replace if shorted

Chassis—Zenith 25EC58
PHOTOFACT—1370-2



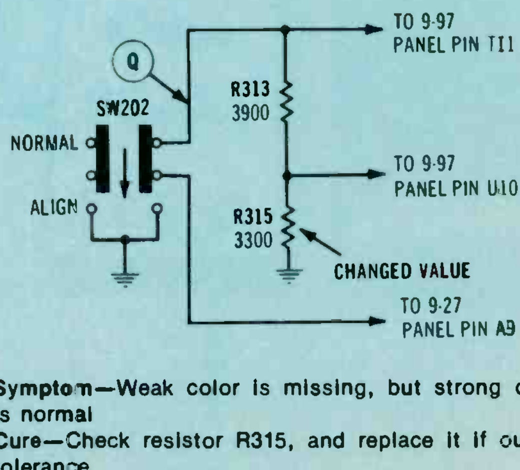
Symptom—No luminance signal and no brightness control
Cure—Check for short from L203 delay line to ground; replace if shorted

Chassis—Zenith 25EC58
PHOTOFACT—1370-2



Symptom—Height varies at bottom of raster
Cure—Check for intermittent CR211 zener and for variations of +24V supply

Chassis—Zenith 25EC58
PHOTOFACT—1370-2



Symptom—Weak color is missing, but strong color is normal
Cure—Check resistor R315, and replace it if out of tolerance

Industrial maintenance with portable scopes

For the field service technician, the oscilloscope is one of the basic instruments for service and maintenance of industrial equipment. These instruments have undergone marked changes in circuitry and packaging brought about by advances in digital displays, circuit miniaturization and microprocessor technology. Covered in this article will be some of the advances in portable scopes and how these advances have made maintenance easier.

Portability and scope features

Selecting a scope for field service and maintenance generally centers on choosing one that's lightweight, rugged, portable and has the features needed for the service being provided. Although the bench scope need not be hampered by weight restrictions, the portable scope has weight limitations and battery operation as key design parameters.

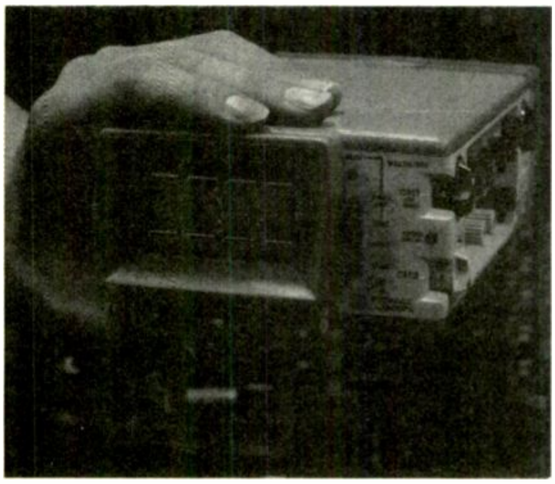
Fortunately, modern circuitry and production techniques have made it possible to manufacture a wide range of scopes specifically for portable use. They have features made possible through circuit miniaturization that previously were expected only in larger, heavier bench models. The result is low weight, low-power consumption and rugged instruments with features to get the job done.

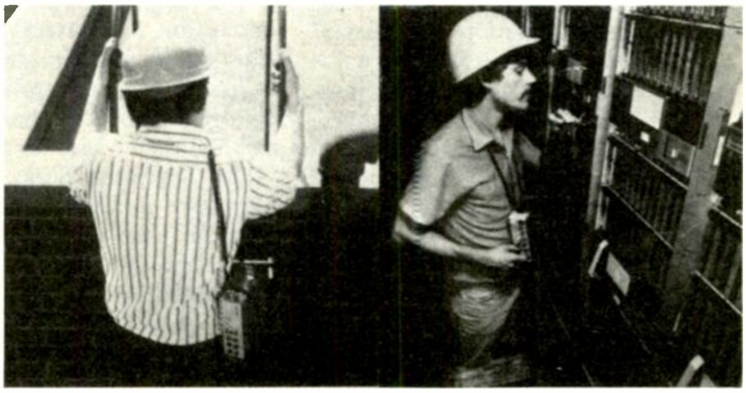
Weight alone is not adequate to classify scopes as being *portable.* Microcircuits have greatly reduced the weight of all modern scopes so that almost all models can be considered as portable scopes by older standards. For the purpose of this discussion, *portable scopes* are considered very low weight, *battery powered* scopes specifically designed for field use.

For portable scopes, other features are added to make them easy to transport, set up and operate—such as multi-position handles for balance and easy viewing. Some miniature scopes feature neck straps for no-hands transportation. Support stands and carts can be added when needed. Built-in, rechargeable batteries are available on some models, and snap-on or freestanding battery packs can be obtained for others.

In recent designs, front panel controls are functionally clustered and color-keyed for quick reference and easy training. Accessory pouches on some models keep everything needed with the scope—including probes.

For added reliability, some manufacturers put samples of every service instrument through rigorous tests. They shake them, shock them, subject them to high and low temperatures, high altitude and high humidity. They're tested for RF radiation and electrostatic discharge. And there's an accelerated life test for reliability purposes. Appropriate components are subjected to salt fog, sulfides, ozone





Miniature scopes, such as the Tektronix 200 series Miniscopes shown here, provide the ultimate in compactness and portability. Weighing less than 4-pounds, they can be carried inside a tool kit.

The digital scope

Features	Benefits
25Ms/sec maximum digitizing rate	High speed to allow viewing of faster signals than previous digital scopes
8-bit vertical resolution	0.391% resolution is equivalent to CRT storage
Display interpolation	Accurate viewing of waveforms even at low sample densities
Envelope mode	Catches glitches that other digital scopes can't Detects aliasing *Babysitting* for service applications
Cursors for time and voltage	Make measurements easily and accurately with improved repeatibility
Pre-trigger viewing	View events happening before trigger event
Expandable, repositionable stored traces	Allows detailed viewing of single shot events after they've been stored Good for comparisons
Stored traces won't fade or bloom	Makes stored signals easier to use
Ground reference is displayed on CRT	Enables voltage measurements with respect to ground
Signal averaging option	Removes random noise from signal Improves measurement capability

Portable scopes

and ultraviolet light tests. And moving parts are life-cycled around the clock. Once they pass these tests, they are ready for the industrial environment.

The scope roundup, featured in this issue, highlights some of the portable scopes currently available for field service and maintenance, but the listing has been limited to scopes in the 10-50MHz bandwidth range. This limitation eliminates some of the miniature scopes with limited features designed to fit into tool kits and ultra-portable scopes having broader capabilities. The following material will briefly describe some of these systems.

Digital—where will it go?

One of the most exciting features to be added to recent scopes is digital storage. Because of the newness of this feature, it's expensive, and not everyone will need it. However, if transient phenomena need to be examined, or if the signal needs to be stored so it can be looked at in a variety of ways, the digital storage scope has no equal. And, as technology continues to advance, these scopes should come down in price so that their unique capabilities can be justified for limited budgets.

The portable scope

As noted, classification of portable scopes is not precise; nearly all scopes can be considered portable from a weight viewpoint. Adding a restriction of battery operation helps clarify the situation, but not completely. For example, Tektronix has two series of scopes considered portable under these terms.

The Tektronix Series 200 Miniscopes are miniature scopes weighing less than 4 pounds and fit neatly in the hand. They have internal NiCad batteries, a bandwidth of 500kHz-5MHz and are designed for the service engineer working far from an ac outlet. In this series there are four different models to select from, depending on the user's requirements.

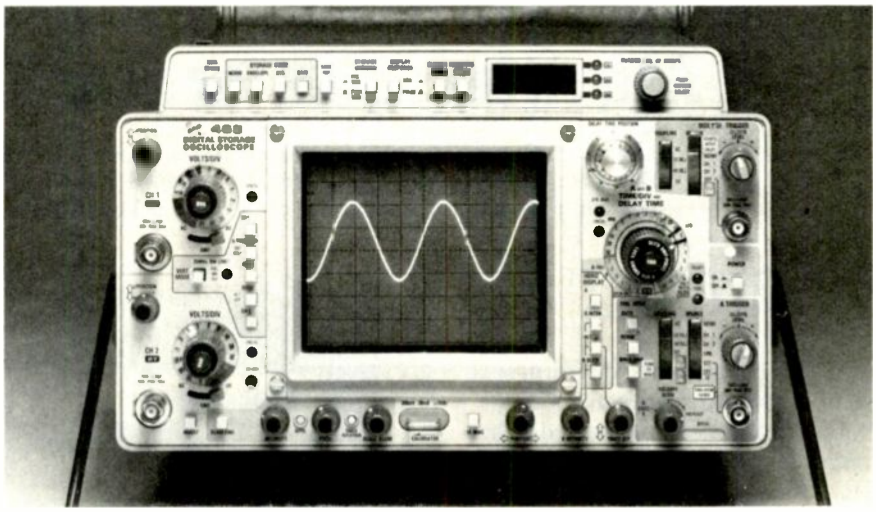
The Tektronix Series 300 Ultra-Portable scopes weigh in at 10½ pounds and provides a wider range of scope features than available in the 200 Series units, including bandwidths to 35MHz. There are three models in this series, of which the 314 and 335 are detailed in the scope roundup in this issue. The remaining model 304 is not included in the roundup because of its 5MHz bandwidth.

Portable scopes are available from a number of sources, and the previous references to Tektronix systems are for examples of industry trends only. To obtain detailed information concerning portable scopes, use the reader service card and the chart below.

Portable Scope Data

□

Scope illustrates design trend



The 468 digital scope

Tektronix has introduced its new 468 digital storage scope, a 33-pound model that uses digital technology and memory to provide an exceptional instrument. Details of this scope are not included in the table because of its extended bandwidth capabilities. However, because this instrument illustrates the trend in future instrument design, it is included in this roundup.

Using state-of-the-art technology advances, the model 468 increases digital storage bandwidth limits, detects alias signals, and corrects envelope error and display jitter.

Priced at $5000, the 468 in the nonstorage mode has all the capabilities of the popular 465B 100-MHz portable scope. In the storage modes, the 468 continues to *drive* like a nonstorage scope; its basic operation is the same as the 465B. The storage mode is selected by pushing a button; waveforms are acquired and stored as easily as they are viewed in the nonstorage mode.

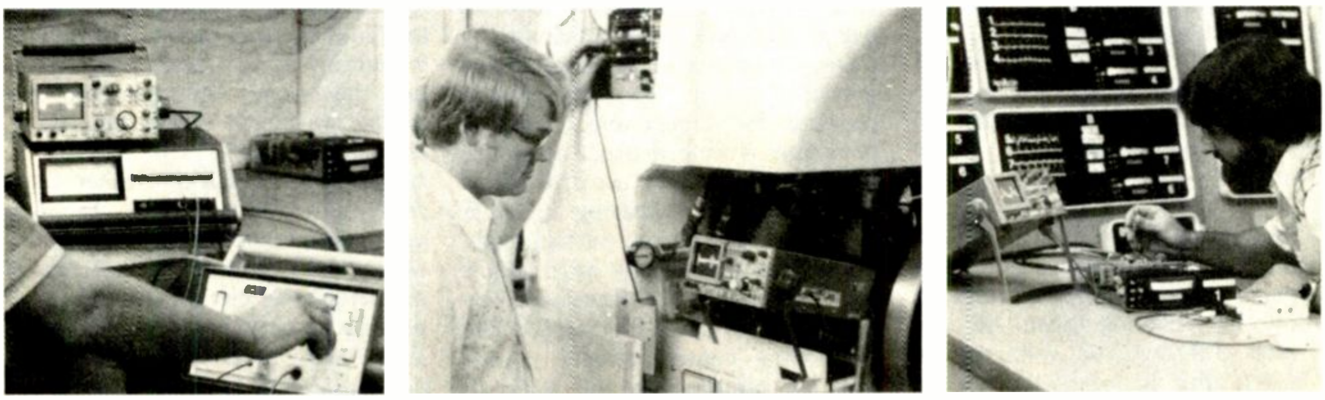
There are no storage level/intensity control interactions. The stored waveform does not bloom or fade positive. These features, along with signal averaging and cursors for time and voltage differences, make operation more convenient for the user and increase engineering productivity.

The 468 has a 25-MS/s, 8-bit digitizer and uses a unique display interpolation technique to achieve a 10-MHz *useful storage bandwidth.* This revolutionary development allows the 468 to perform faster than other digital storage scopes and increases the range of signal frequencies that can be stored and displayed.

Useful storage bandwidth is a specification developed by Tektronix to enable users to compare digital storage scopes with each other and with conventional storage scopes. It highlights the maximum frequency sinewave that can be stored usefully in a single sweep.

Usefully is a visually usable and accurate representation of a waveform—one with less than 5% envelope error. The concept is based on digitizing rate and display type utilized and asserts that it takes more dots to define a waveform than when dots are joined by vectors. The 468 interpolated display requires only 2.5 samples per cycle to accurately display sinusoidal signals and achieves a useful storage bandwidth of 10MHz.

The envelope mode, an exclusive design feature of the 468, uses dual sampling rates and records maximum and minimum values of a waveform envelope into memory over a selectable number of sweeps (2 to 256, plus continuous setting). It can capture narrow pulses on long sweeps and is useful for glitch catching, viewing waveform excursions and detecting aliasing. □



Ultra-portable scopes, like these 300 Series Tektronix units, are particularly useful in servicing medical electronic equipment, remote computer terminals, and other sophisticated industrial equipment that requires broader bandwidths and other features not available in the miniature scopes.

Practical scope tips part 1

Acquiring skills for bench servicing

Operating a modern triggered-sweep scope appears to be complicated; it isn't. But skill, accuracy and speed can be attained only by following a definite procedure based on a knowledge of how the scope works.

By Gill Grieshaber, CET
Gill's Color TV Service

Sencore SC-60 is a new 60MHz scope that will be covered in *Reports from the Test Lab* in a later issue.

Typical problems encountered when operating scopes are:

- Too much time is wasted when trying to obtain *any* light on the CRT screen. There should be an easy way of producing either line or waveform to prove the scope adjustments are satisfactory.
- Obtaining a stable waveform is confusing because of the many controls and switches. The methods and adjustments should be simplified.
- There are unanswered questions about which probe is best for a specific measurement and about when a low-capacitance probe should be used.
- Procedures for performing uncommon scope tests are not well known. These include measuring dc voltages, measuring relative phase, expanding waveforms for detailed analysis, finding dcV levels of waveforms and stabilizing the display by triggering from an external signal.
- After a waveform is obtained, it is difficult to evaluate waveshapes that are different from the normal one on schematics.

Preliminary concepts

Four sections of a scope are involved in obtaining a sharp stable waveform.

Cathode-ray tube—Correct CRT dc voltages are necessary before any brightness (in the form of lines or waveforms) can be seen on the screen. Only two dc voltages are adjusted during operation: focus and intensity. Incorrect focus voltage blurs the trace but does not reduce the brightness of it. However, a CCW setting of the intensity control can eliminate all screen brightness. Failure to trigger also eliminates brightness, but triggering can't be tested easily unless the CRT is ready to show a waveform.

Vertical channel—The height of a scope waveform is produced by whatever signal is in the vertical channel, and a sample is used to trigger the sweep into action. A waveform height of more than one graticule division (or centimeter) is required for dependable triggering (locking). Waveforms that are taller than the CRT screen are difficult to see, sometimes appearing to be a lack of trace. Also, vertical-positioning controls usually have such a wide range that the waveform can be moved off the CRT screen. The positioning control should, therefore, be adjusted to the approximate center of rotation.

Triggering circuit—A sample of the vertical signal is filtered and sent to the triggering circuit. *User adjustments of the triggering-level control determine where (on the sample vertical signal) triggering occurs.* This triggering activates the horizontal sweep; without triggering there is no sweep and no CRT light, lines or waveform (unless auto-triggering is selected). Auto-level triggering produces either a horizontal line or an unlocked waveform. A line proves the CRT has the proper voltages; an unlocked waveform shows everything is working, but the sweep is triggered automatically rather than from the vertical signal. In that case, proper triggering must be obtained by skillful adjustments of the triggering circuit switches and controls according to the type of signal being scoped.

Horizontal-deflection circuit—Deflection of the CRT beam from left to right is initiated by a pulse from the triggering circuit. After the triggering, the sweep operates by itself for a period of time selected by the time/division switch and its variable control. Without some kind of triggering, there is no sweep and no light on the CRT screen. Also, the horizontal-positioning control can move the waveform off screen. This positioning control should be adjusted to the center of rotation. After a line or waveform has been obtained, the horizontal-positioning control can be readjusted so the trace begins at the left edge of the graticule.

Although many controls in these four scope sections must have approximately correct adjustments before anything can be seen on the CRT screen, much time can be saved either by presetting the controls or by retaining the adjustments used for the previous scope operation. That way, just a few controls will require minor adjustments; this is much faster than beginning with all controls set to some arbitrary position.

Scope horizontal deflection

Horizontal deflection in a triggered-sweep scope has three stages:

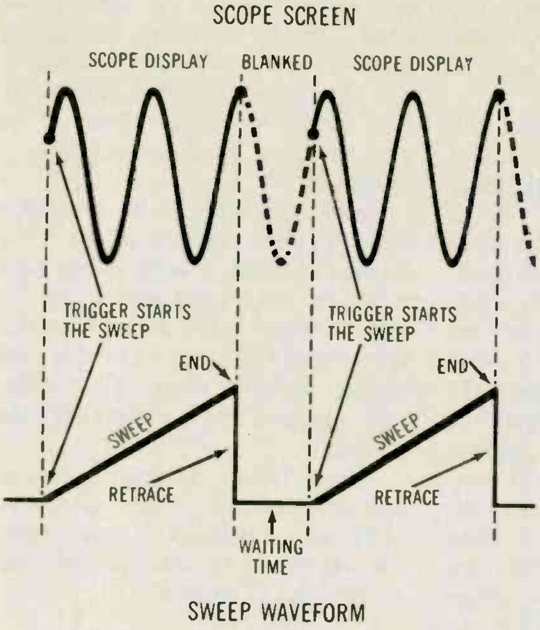


Figure 1 Controls and voltage comparators produce triggering at a preselected voltage level in the vertical signal. Triggering initiates horizontal sweep, which continues for a time determined by time/division switch settings. After sweep and retrace are over, there is no sweep until triggering occurs next from another appearance of the preselected voltage level in the vertical signal. The sinewaves at the top show what is displayed on the scope's CRT screen (of course, repetitive displays cover the same area of the screen). Below, the sawteeth and waiting times reveal the horizontal-sweep waveform that produced the sinewaves.

Bench servicing

resting, triggering and *sweeping.* Of course, this sequence is repeated as long as the vertical signal and the triggering adjustments remain the same.

When power is first applied, the sweep is resting (there is no deflection). Triggering occurs when the vertical signal reaches a voltage previously selected by several triggering-circuit controls. This triggering forces the timed sweep to begin. Horizontal deflection starts at the left and stops at the CRT right edge before rapidly retracing (the beam is blanked during retrace) to the left edge. Following retrace, ***the sweep circuit rests until triggered again.*** Deflection is not continuous. This sequence is illustrated in Figure 1. It is important to the understanding of scope adjustments and it should be studied and memorized.

Notice that a triggered scope does not lock as a recurrent type does. There is no mathematical relationship between the repetition rates of vertical signal and horizontal sweep. A triggered scope shows whatever section of the vertical signal occurs during the sweep time. A thousand cycles or a fraction of one might be displayed. If the waveform and the triggering adjustments produce triggering at the identical point on each cycle of the waveform, the displayed picture will be stable (locked). Actually, the words locked or locking should not be used with descriptions of triggered scopes. An unsynchronized waveform produced by auto-triggering is merely not triggered properly by the signal. *A properly triggered waveform always is synchronized.*

There are a few rare cases of peculiar waveforms causing false triggering. Ringing or extra pulses that occur immediately after the end of sweep sometimes can cause triggering that begins before the vertical signal reaches the proper point. A change of time/division adjustment usually cures this type of false triggering.

Adjustment examples

Figure 2A shows an improperly displayed waveform that can be corrected easily by horizontal and vertical centering. A sequence for correcting three waveform problems is pictured in Figure 2B.

One pitfall in knowing which adjustment to turn (and which direction to rotate it) comes with sweep times that are unusually short or excessively long relative to the signal-repetition rate (Figure 3). The waveform might appear to be one straight line or perhaps a rectangle.

Pulses are difficult to recognize when they are taller than the CRT screen, or when a long sweep time produces too many pulses on the screen (Figure 4). Fast rise-time squarewaves (Figure 5) also are almost invisible when the positive and negative peaks are off the screen.

When falsely triggered by an auto-level circuit, which shows an unlocked waveform, squarewaves can appear to be two parallel horizontal lines (Figure 6).

Presetting scope controls

When a scope is operated several times per day, and the controls are not disturbed by dusting or moving the scope, the knob and switch settings *should not* be restored to preset points before each use. For instance, suppose the scope had shown TV horizontal-oscillator waveforms previously. When called on to show power-supply ripple, it

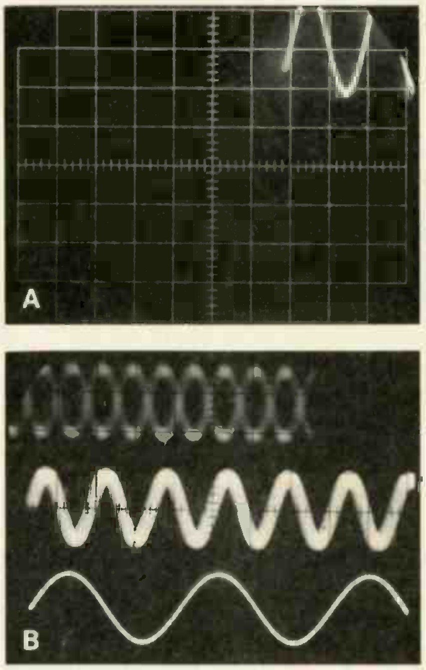


Figure 2 (A) shows a properly triggered sinewave display in a corner of the CRT's screen. Vertical and horizontal positioning controls need adjusting. (B) Three consecutive adjustments are shown here. The top trace shows a blurred off-center unlocked signal produced by auto-triggering. The center trace shows a sinewave pattern after it is properly triggered and centered. It is still out of focus. The bottom trace is the same signal after focusing and shortening the horizontal sweep time to produce 2¼ cycles.

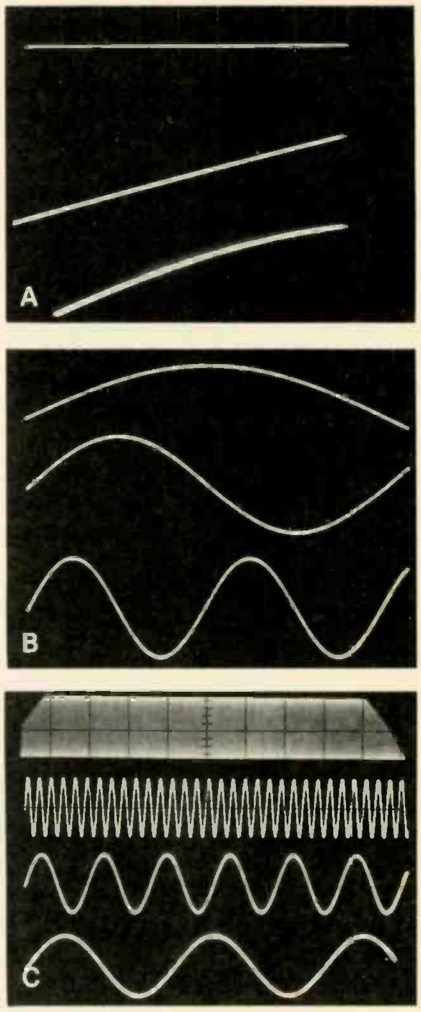


Figure 3 (A) When adjustment of the triggering-level control stopped trace movement, the waveform was just a straight and dim horizontal line (top trace). An increase of sweep time tilted and brightened the line (center trace) and another increase revealed a curve (bottom trace). (B) As the sweep time was increased in steps, the top trace showed an up and down curve, the center trace revealed about 1 cycle of a sine wave and the bottom trace was 2+ cycles of sine wave. (C) At the other extreme, a stable display appeared to be solid and without cycles (top trace). However, the second trace shows many sinewaves after the sweep time was shortened by two switch positions. Additional decreases of sweep time (third and fourth traces) decreased the number of cycles to about 2½. Notice that none of these signals required any readjustment of triggering controls.

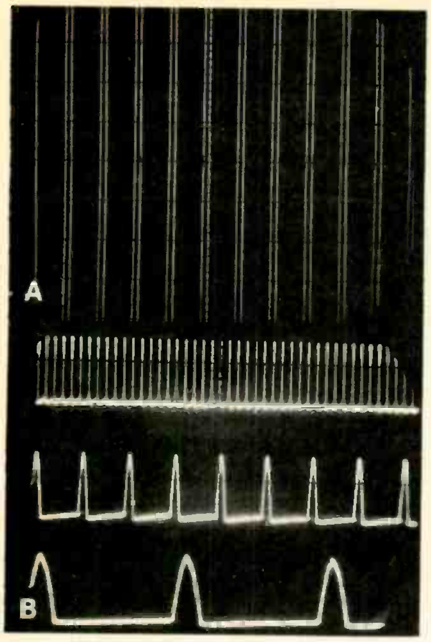


Figure 4 (A) A number of dim vertical lines proved to be TV horizontal-sweep pulses (similar to those in the next photograph) when the vertical sensitivity volts/division control was turned two positions CCW. (B) The top trace shows TV horizontal-sweep pulses that resemble a comb because there are too many. After the scope sweep time is increased in steps, the pulses become fewer and easier to examine (center and bottom traces).

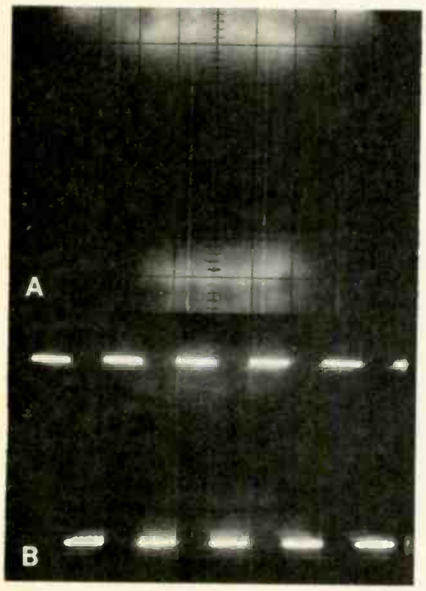


Figure 5 Pulses and squarewaves with fast rise times become almost invisible when their height exceeds the CRT screen. (A) Only some blobs of brightness at top and bottom from the PDA action and several dim vertical lines indicated the scope was working. (B) After the volts/division vertical-sensitivity switch position was turned CCW about two positions, it was evident the waveform was squarewaves. Notice that the excessive height had nothing to do with the triggering.

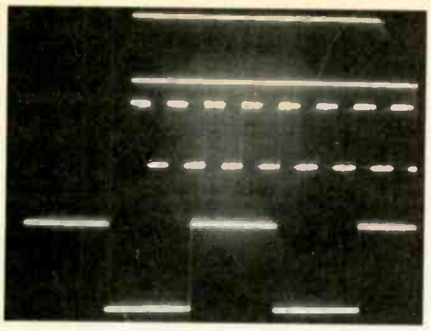


Figure 6 Several waveform corrections are illustrated. The top trace appears to be two parallel horizontal lines. However, this is typical of squarewaves when triggered by automatic action rather than true signal triggering. The center trace proves, after a small adjustment of the triggering-level control, that the signal is squarewaves. However, there are too many cycles and the waveform is off center. The lower trace shows a correct display of the squarewave signal.

is necessary only to change the time/division switch position for a longer sweep time and increase the vertical sensitivity with the volts/division control.

However, if a scope is used infrequently, valuable time can be saved by presetting some controls before each use. For high quality scopes that have regulated power supplies, a preliminary adjustment of the intensity control to almost maximum (fully CW) will allow a waveform to be seen when the sweep is triggered. The intensity can be reduced later if necessary. Sharper waveforms are obtained at lower intensities (reduce trace brightness), and a major change of intensity requires a slight change of focus-control setting if maximum sharpness is desired.

Always select the vertical channel ac-coupling mode until a waveform is obtained. This reduces the possibility that a waveform has been moved off the visible part of the screen. At the same time, adjust vertical and horizontal positioning control to the center of rotation.

If the approximate amplitude and frequency of the signal under test are known, the vertical volts/division and sweep time/division switches should be preset for those values. It is simple to touch up the adjustments later. Table 1 shows the sweep time/division figures for representative repetitive frequencies.

Next, operate with automatic triggering. Or, if the scope does not have that feature, adjust the triggering level control to the zero setting (where triggering occurs at the center of symmetrical waveforms).

Always be aware of the problem caused by excessive amplitude waveforms that have peaks extend-

Frequency		Seconds	For 2 cycles per screen, set sweep time/div for:	
20	Hz	.05	10.0	MS
50	Hz	.02	4.0	MS
60	Hz	.0166	3.32	MS
100	Hz	.01	2.0	MS
120	Hz	.0083	1.66	MS
400	Hz	.0025	0.50	MS
1000	Hz	.001	0.20	MS
5000	Hz	.0002	40.0	μS
10000	Hz	.0001	20.0	μS
15734	Hz	.0000636	12.8	μS
100000		.00001	2.0	μS
1	MHz	.000001	0.2	μS
3.58	MHz	.00000028	0.056	μS

Reciprocal formulas for sweep time versus repetition frequency

1 ÷ TIME in seconds = FREQ in Hz
1 ÷ TIME in mS = FREQ in kHz
1 ÷ TIME in μS = FREQ in MHz

1 ÷ FREQ in Hz = TIME in seconds
1 ÷ FREQ in kHz = TIME in mS
1 ÷ FREQ in MHz = TIME in μS

Table 1 Many often-used frequencies are listed with the scope sweep time/division adjustment that show 10 cycles (one per graticule space), 2 cycles or 1 cycle per screen. Included also are the formulas for changing sweep time/division figures to repetitive frequency, or frequency to scope sweep time.

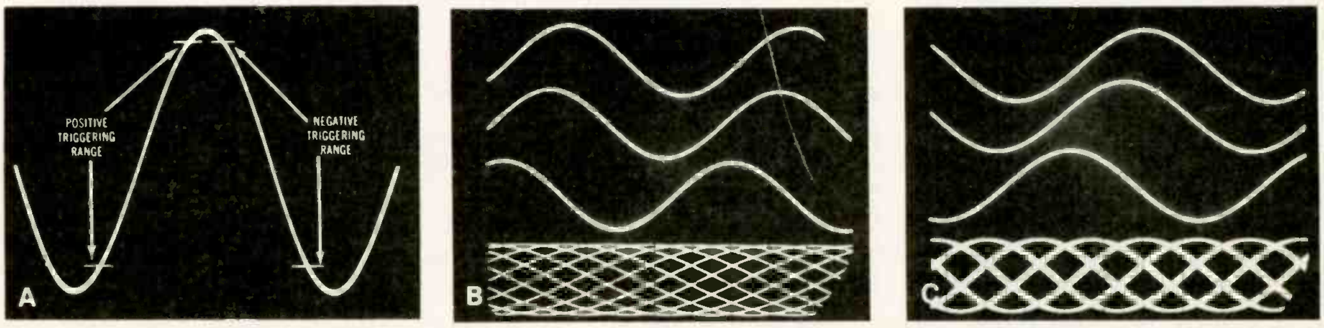


Figure 7 These waveforms illustrate how triggering operates at different voltage levels. (A) A sinewave scope pattern has been marked with a positive-going slope (upward to the right for positive triggering) and a negative-going slope (downward to the right for negative triggering). *When triggering on the positive slope is desired, the trigger-level switch must be placed in the positive position,* and the negative position must be selected for negative or downward slope. (B) the range of positive-slope triggering is shown by these traces. First trace (top) shows triggering (located by beginning of waveform) near the bottom of the positive slope. Second trace shows triggering at about the waveform's average voltage. As the triggering level control is turned more CW, the trace is triggered near the top (third trace). However, when the control is turned farther CW, proper triggering is lost and the auto-level circuit substitutes an unlocked waveform (trace four). (C) Similar actions occur after the triggering polarity is switched to negative. The top trace shows triggering near the positive tip. CCW rotation of the level control moves triggering to the average voltage of the waveform (trace two). This is the point of best stability. Additional CCW rotation moves the triggering near the negative tip (trace three), but still on the same slope. Trace four shows the unlocked waveform when another CCW rotation moved the triggering point to dangerous areas at the tip or the next positive slope. Correct triggering was eliminated. *Triggering is not possible at waveform extreme tips.* Adjusting the trigger-level to the center position gives best stability with sine, square, triangle and sawteeth waveforms (all symmetrical waveshapes).

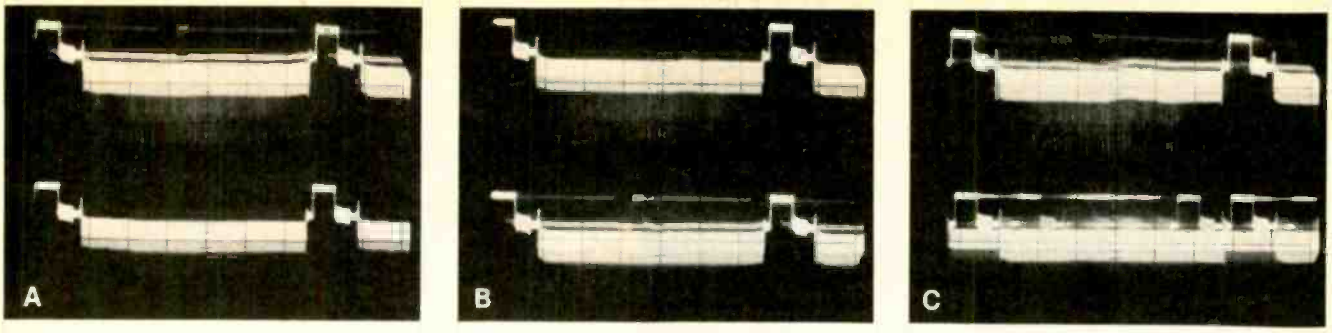


Figure 8 These are the results of testing various triggering filters and modes on composite NTSC video when scoped at TV horizontal rate. (A) In the *ac* triggering mode, stable triggering could be obtained when the level control selected the rising edge of horizontal sync. Other triggering points allowed the stability to vary unpredictably. However, triggering operated also on the vertical-interval serrated pulses, which allowed ghost images of the vertical interval to be seen (top trace). When changed to *LE-reject* mode (low frequencies are attenuated in the signal that activates triggering), best triggering occurred again on the sync leading edge, but the retrace ghosts were weaker (lower trace). (B) The top trace shows the best rejection of retrace ghosts when *HF-reject* (which attenuates high frequencies) mode was selected. This filter, incidentally, delays the triggering phase, so triggering appears to occur on the sync-pulse top. When the *video* mode (which adds a TV-type sync separator) was used, stability was excellent, but retrace ghosts were prominent. (C) External sync provided by applying TV-deflection pulses to the *ex-trig* jack gave excellent stability without critical level adjustments. Some vertical interval pulses were visible (top trace). False triggering (lower trace) made the FIX features unusable when the triggering signal was taken from channel A. This type of automatic triggering disconnects the usual triggering level control and always triggers at the *average* voltage of the triggering waveform. With video, solid triggering is prevented by chroma and video signals at the average voltage point. FIX is not recommended for use with video unless external sync is used. This can be a sample of horizontal-sweep pulses or sync pulses obtained from a TV receiver sync separator.

ing past the screen edges and the auto-triggered (but not locked) squarewaves that appear to be two parallel horizontal lines.

When a waveform cannot be found, vary the waveform height with the volts/division switch and also vary the position of the sweep time/division switch to find out whether these settings are causing an obscured waveform.

Problem waveforms

The most difficult waveform to lock properly (except digital signals) is NTSC composite video, either from generator, videocassette recorder or TV receiver. Composite video is a mixture of many frequencies, and the vertical-retrace section is different from the lines with video. In addition, video has constant amplitude variations and waveform changes.

An understanding of the problem and its several solutions are acquired best by studying scope triggering and then video waveform.

Simple scope triggering—Sinewaves are ideal for demonstrating scope triggering. Figure 7A shows a scope sinewave with the sections marked where triggering on the positive-going slope and triggering on the negative-going slope occur. Figures 7B and 7C show actual triggering on those two slopes.

The transitions of pulses and squarewaves are very rapid positive-negative-going slopes; these principles apply to them also.

Video triggering—Problems arise with composite video waveform because the best pulse for triggering is the horizontal-blanking pulse, which is surrounded by moving video pulses of similar amplitude.

Stable triggering can be attained by careful selection of the horizontal sync's leading or trailing edge. Or a ringing pulse at either edge can be selected. However, the stability is marginal and critical to obtain because of the constantly changing amplitude and the presence of different sync pulses during vertical retrace times.

Figure 8 shows and explains the results of testing horizontal-rate video with various combinations of triggering filters plus external-sync triggering and the FIX type of triggering (at the average amplitude). The internal sync separator (called video in this machine) gave good results, as also did the use of horizontal-sweep pulses brought in through the external-triggering jack.

When triggering is attempted at vertical rate, however, there are fewer conditions that give acceptable results. As shown in Figure 9, only the internal sync separator or vertical sweep connected to the external-triggering jack gave good stability.

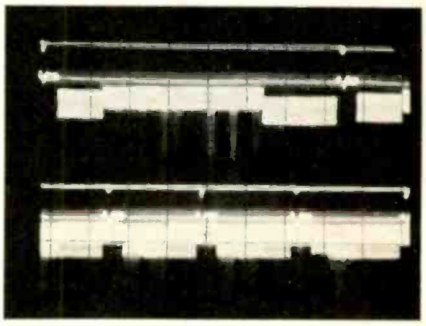


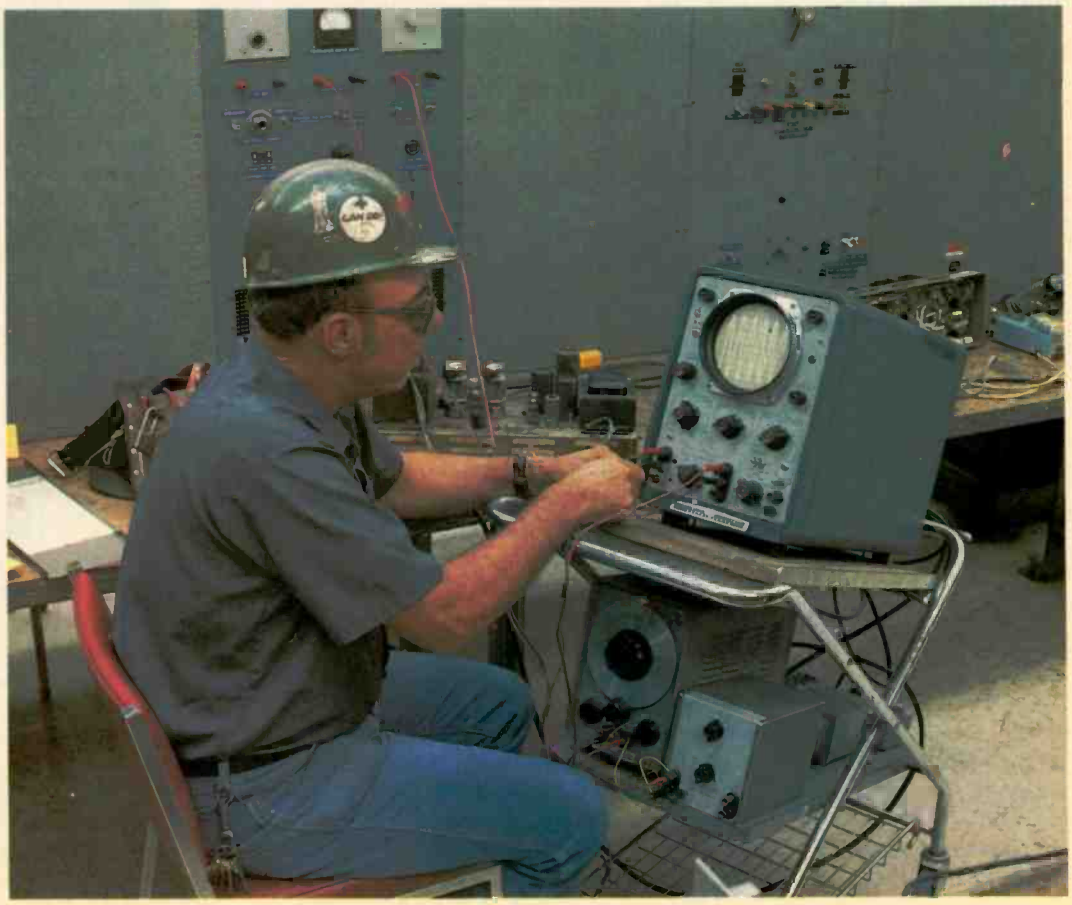
Figure 9 The top trace shows good stability when the scope's sync separator was used for triggering. A sample of vertical sweep from a television receiver provides good stability when applied to the external-triggering jack. The lower trace shows the jumble of vertical fields that resulted for all other kinds of triggering. The FIX mode had good stability with external triggering, but not for internal sync-separator triggering.

Next month

In Part 2, many advanced scope techniques and measurements will be described. These will include: how to minimize hum and signal by subtracting the two vertical signals; how to prevent waveform changes or ringing in certain signals; how to measure amplitudes above the range of the scope; how to display VITS and VIR signals; and various ways of expanding waveforms to reveal small details. □

Industrial MRO & Consumer Servicing

New scope features



Scope features and technical specifications are translated into additional functions and benefits to the scope operator. Included are comparative tables listing condensed specifications of many scope models, along with reader service numbers needed to obtain additional manufacturer's product literature.

By Carl Babcoke, CET, and the **Electronic Servicing** staff

Successful salesmen describe a product's feature and immediately list all its benefits. The same principle applies to evaluation of new scopes: each feature must provide a benefit if it is to have value.

Solid state

Except for the cathode-ray tube (CRT), all new scopes have solid-state devices and no tubes. The conventional benefits of solid-state components apply to scopes. In addition, several scope improvements are possible because of solid-state. Various types of stability are examples. A vertical-gain calibration control is no longer required on the front panel because the gain changes are minimal. A squarewave of known amplitude is provided primarily for adjustments of low-capacitance probes, although the same waveform allows an amplitude-calibration test when desired.

Dc response in a scope's vertical amplifiers requires direct coupling between stages, increasing the possibility of the waveform drifting up or down and laterally on the CRT screen. Solid-state technology minimizes waveform-position drift. This is important because these new scopes have high vertical gain.

The following explanations of new scope features and benefits are arranged in the same general sequence as the scope-comparison charts.

Recurrent vs. triggered

The previous battle between recurrent and triggered sweep is over. Recurrent lost. Recurrent-sweep scopes for sale today are low-cost models designed for production line or school uses.

Many technicians have old recurrent-sweep scopes that have yet to be replaced. Perhaps one reason is the mistaken belief that scopes are too complicated for continuous bench troubleshooting. Therefore, the old clunker is sufficient for the few cases in which other methods fail. Both ideas are incorrect. These new scopes are easy to operate, and the needed skills of waveform diagnosis can be obtained quickly. Technicians using a modern scope as a second choice of test instrument (a digital multimeter is first) find they save large amounts of diagnostic time and reduce the number of components replaced by *shotgunning*. To provide maximum usefulness, a scope must have triggered sweep. Recurrent-sweep types have many limitations.

Figure 1 uses waveforms to show some differences in operation of recurrent vs. triggered scopes. Of course, waveform photographs cannot properly reveal the instability and the drifting adjustments that plague the locking of recurrent scopes. A comparison with a trig-

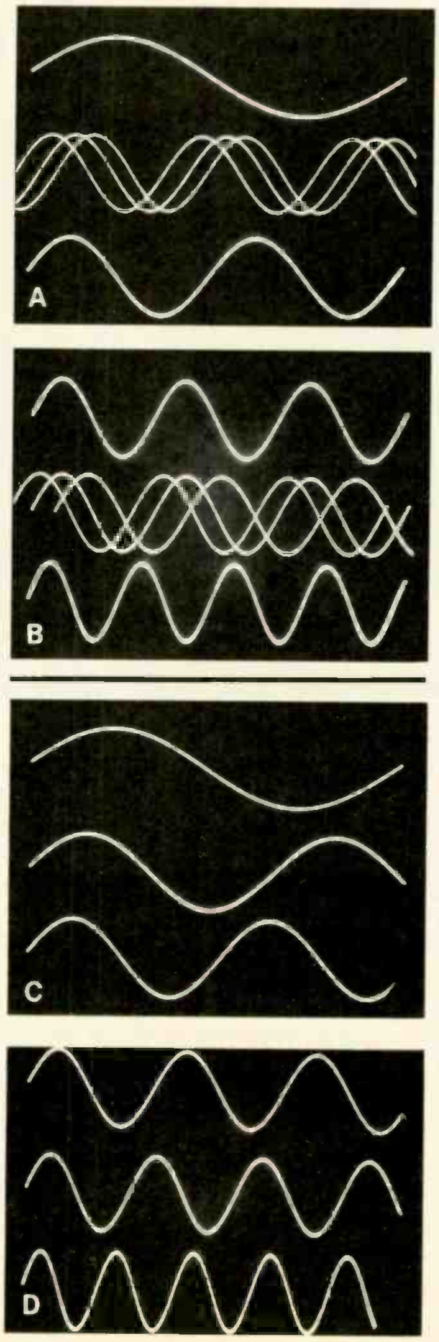


Figure 1 One advantage of triggered-sweep over recurrent is the ability to show any number of waveform cycles or any fraction of one cycle: (A) With recurrent sweep, it is impossible to show less than one cycle (top trace). Then as the sweep frequency is decreased, locking is lost and the screen shows a jumble of cycles (center trace). Two cycles are shown when locking next is achieved (bottom trace—sweep frequency is half the signal frequency); (B) Additional decrease of sweep frequency produces another mode of unlock and then shows three cycles (top trace—sweep frequency is a third of the signal frequency). The center trace shows another out-of-lock condition followed by display of four cycles (bottom trace—sweep frequency is a fourth of the signal frequency). And so on as far as the sweep range allows. By comparison, triggered sweep requires "locking" just once per waveform; (C) Triggering has provided a waveform and the proper sweep time shows one cycle (top trace). As the variable time/division control is rotated to give a longer sweep time, the waveform gradually compresses to two cycles (center trace), and then to three cycles (bottom trace); and (D) Further decrease of sweep time gradually changes the waveform to three cycles (top trace), 3½ cycles (center trace) and slightly more than four cycles (bottom trace). No instability or lack of "locking" is found, and the variation of cycles is gradual without gaps. Of course, *decreased* sweep time stretches the top trace of A to any fraction of one cycle. Extreme expansion can show a small section of one cycle as though it is a straight line.

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gered scope provides adequate proof. For example, a triggered scope can show the same stable (locked) waveform one day as it did on the previous day before the bench power was turned off. Stable triggering is not upset by signal amplitude or frequency changes or by ordinary line-voltage variations.

Vertical sensitivity

Using an average scope of several years ago, a vertical input of 0.05VPP would deflect the CRT beam one graticule division. That is 0.05V-per-division or 50mV/div, which cannot compare with the 10mV/div to 1mV/div of newer scopes (see comparison charts). Many older scopes were not designed for shielded cables or low-capacitance probes. By contrast, most new scopes have input connectors for shielded cables and sufficient gain to tolerate 10X-loss low-capacitance probes.

Current and future requirements should be considered when selecting a new scope. Tube-type color-TV receivers, for example, seldom had signal amplitudes of less than 3VPP. Power-supply ripple might have been lower, but it was not necessary to observe it in large detail. A maximum scope sensitivity of 50mV/div was adequate with a probe that gave 10X loss.

A transistor wired as a common-emitter audio amplifier without negative feedback or degeneration might have a base signal amplitude of about 0.005VPP (5mV) for class A operation. If the scope had 50mV/div maximum sensitivity (and operated without a probe that gives loss), the waveform would have a height of only 1/10 divisions on the CRT screen. Obviously, such low sensitivity severely limits that scope for use with solid-state components.

Most new scopes have maximum vertical sensitivity from 10mV/div to 1mV/div. Figure 2 shows comparisons of relative waveform amplitudes when a 0.05VPP sinewave is viewed on scopes having maximum vertical sensitivities of 10mV/div, 5mV/div, 2mV/div and 1mV/div. These traces were made through the usual probe that gives a X10 loss. Identical signal amplitudes would be obtained if the signal was reduced to 0.005VPP and the probe changed to the 1X direct type without loss.

A 2mV scope can be used for months without needing more sensitivity than the 20mV effective value obtained with the X10 probe. If more sensitivity is needed, changing the probe switch to X1 will give 10 times additional deflection, but the drawback of increased loading from the cable and stray capacitances.

The vertical maximum sensitivity of new scopes is satisfactory for the present, but it might become marginal as transistors are replaced by ICs.

Scope probes

These new high-performance scopes should *always* be operated with the probes designed for them. Direct (no attenuation) probes do not require adjustment. Low-capacitance probes must be adjusted to each individual scope. Improper adjustment distorts complex waveforms and ruins the amplitude-calibration accuracy at high frequencies.

Each low-capacitance (10:1, X10 or low-cap) probe has an adjustable capacitor in the probe body or in

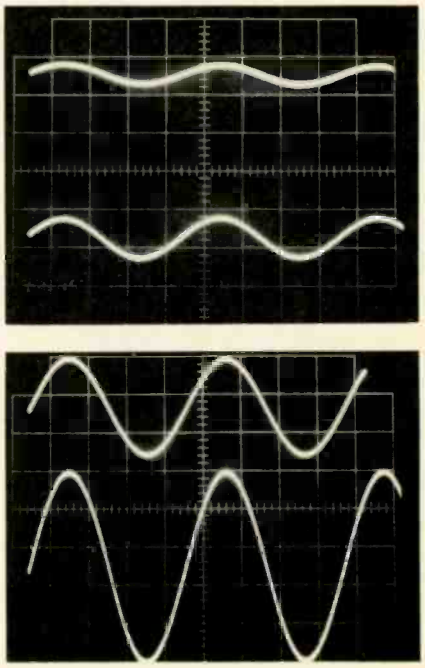

Figure 2 These scope waveforms show the maximum waveform height obtained by an X10 low-capacitance probe from a 0.05VPP sinewave. (A) Maximum vertical sensitivity was 10mV/division (top trace) or 5mV/division (lower trace). (B) Maximum vertical sensitivity was 2mV/division (top trace) or 1mV/division (lower trace).

Problem:
Build an oscilloscope light enough to carry in the field, yet sophisticated enough to use in the repair shop. And bring it in at under $600.

Solution:
Non-Linear Systems' MS-230. A 3 lb. 10 oz. miniscope.

At 3 lbs. 10 oz., the MS-230 is the lightest miniscope around. Now you can take the scope to the problem. Or bring the problem to the scope.

It's easy to get carried away with the MS-230. Our remarkable, new 30-megahertz, battery-operated, dual-trace miniscope. At 3 lbs. 10 oz., it's the smallest, lightest miniscope in the field today. Suddenly, portability's not a problem anymore.

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Sets up shop. Makes housecalls. The state-of-the-art MS-230 is at home anywhere there's a need to accurately test or measure electronics equipment.

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What's more, the versatile MS-230 is perfect for servicing microcomputer systems, maintaining avionics equipment and diagnosing sophisticated medical equipment.

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We also make miniscopes to match other budgets and needs. Take the MS-215, for example. It's a 15 MHz, dual-trace scope priced at $465.45. Or the MS-15, 15 MHz, single-trace at $349.80.

And each model is available with optional accessories to help you get the job done. Like a 10:1, 10 megohm probe and leather carrying case with shoulder strap and belt loop.

When it comes to portable, affordable, accurate miniscopes Non-Linear Systems leads the way.

MS-230 at a glance

Vertical Bandwidth:	30 MHz
Deflection Factor:	10 mV/div to 50 V/div, 12 calibrated ranges
Input Impedance:	1 megohm in parallel with 50 pF
Time Base:	0.05 μSec/div to 0.2 Sec/div, 21 calibrated ranges
Horizontal Bandwidth:	200 kHz
Trigger Modes:	Automatic, Internal, External and Line
Power Sources:	
Internal:	Rechargeable lead acid batteries
External:	115 VAC or 230 VAC, 50-60 Hz via plug-in transformer
Size:	2.9" H x 6.4" W x 8.6" D (74 mm x 163 mm x 218 mm)
Weight:	3 lbs. 10 oz. (1.65 Kg)

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Circle (10) on Reply Card

Scope roundup

the connector at the scope end of the shielded cable. This adjustment is made while viewing the calibration squarewave on the CRT screen.

Several old and new scope probes are shown in Figure 3.

Three brands of probes were tested with a digital-readout capacitance meter. One old probe measured 24.2pF in 10:1 low-cap position and 88pF for direct 1:1 when disconnected from the scope. The readings increased to 28.3pF and 56nF when the probe was connected to scope. A new Sencore low-capacitance-only probe measured 22.2pF away from the scope and 23.6pF connected. A new B&K-Precision probe at the X10 position measured 20.3pF by itself and 22.7pF connected to the scope. Switching to X1 position gave 28.4pF alone and 28nF with the scope. Perhaps a measurement of stray capacitances is not valid when made by dcV charging and discharging (rather than an ac bridge), because these readings are higher than typical 9pF to 15pF *ratings* for low-capacitance probes. However, these measurements proved the low-cap function was effective in reducing the capacitance loading of probes.

Figure 4 illustrates squarewave degradation that occurs when a direct 1:1 probe is connected to a 11,000 Ω circuit impedance. The

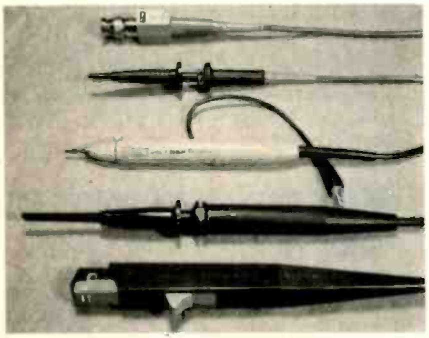


Figure 3 Scope probes are available in many different forms. The top two devices are the probe and scope connector of a Tektronix probe. The adjustment screw is in the connector block. In the center is an old (but still operative) RCA X1/X10 probe. Second from the bottom is an older B&K-Precision probe. It and the Tektronix have hook connectors with spring-loaded insulating covers. At the bottom is a Tektronix current probe for ac-current measurements without breaking of the circuit.

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
B&K-Precision							
1405	10mV/div	5MHz	.....	.....	.....	.....	10Hz-110kHz
1432	2mV/div	15MHz	24ns or less	.....	X	.....	.5μs-.5s per div
1466	10mV/cm	10MHz	35ns or less	.....	.....	.....	1μs-.5s per div
1476	10mV/cm	10MHz	35ns or less	.....	X	.....	1μs-.5s per div
1477	10mV/cm	15MHz	24ns or less	.....	X	.....	.5μs-.5s per div
1479A	5mV/cm	30MHz	11.7ns or less	X	X	.....	.2μs-.5s per div
1520	5mV/cm	20MHz	17.5ns or less	.....	X	.....	.5μs-.5s per div
1530	2mV/div	30MHz	11.7ns or less	X	X	.....	.2μs-5s per div
1535	2mV/cm	35MHz	.....	X	X	.....	.1μs-5s per div
1420	10mV/cm	20MHz	17.5ns	.....	X	.....	1μs-.5s
1500	5mV/div and 1mV/div	100MHz	3.5ns	X	4-trace	.....	Time base "A" 20ns-.5s Time base "B" 20ns-50ms per div
Caywood Electronics							
Millen 90942	No amplifier 90928 amplifier available 39V, peak to peak per cm	No amplifier	....	....	....	....	No sweep
Millen 90912	No amplifier 90928 amplifier available 22½V p-p per cm	.....	.....	.....	.....	.....	No sweep
Millen 90913	No amplifier 90928 amplifier available 5.7V p-p per cm	.....	.....	.....	.....	.....	No sweep

Horiz. Amp Band-width	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
dc-250kHz	.....	.....	.....	.....	• Recurrent sweep	17
dc-1MHz	X5	.....	X	X	• Battery option • Ch. 2 polarity invert	
dc-1MHz	X5	.....	X	X	• Auto level—displays baseline with no input signal	
dc-1MHz	X5	.....	X	X	• Differential inputs • Auto-level	
dc-1MHz	X	.....	X	X	• Differential inputs	
dc-2MHz	X5	.....	X	X	• Ch. 2 polarity invert • Differential inputs • AM detector	
dc-2MHz	X10	.....	X	X	• Independent selection of chop or alternate display • Ch. 2 invert	
dc-2MHz	X5	X	X	X	• Ch. 2 polarity invert • Single-sweep hold-off	
dc-2MHz	X5	.....	X	X	• Ch. 2 polarity invert • Uncal. condition LEDs • Single sweep • Norm/chop sweep select	
dc-1MHz	X10	.....	X	X	• Mini scope • Battery option	
dc-5MHz	X	X	X	X	• Dual independent time bases • 50 Ω and 1 M Ω inputs • Alternate time base operation • Ch. 1, A gate, B gate outputs	
No amplifier 90928 amplifier available	.....	.....	.....	.....	• 2" module scope	18
.....	.....	.....	.....	.....	• 2" module scope	
.....	.....	.....	.....	.....	• 1½"x3" module scope	

squarewave repetition rate is 16kHz (approximately TV horizontal-sweep frequency), which shows the possible loss of video-signal sharpness from a direct probe. Notice that both the scope waveform and the TV video would be affected the same because the excessive probe/cable capacitance connected to the video signal is responsible.

There are two advantages of low-cap probes, less loading on tested circuits because of higher impedance and reduced capacitance at the probe tip. The only disadvantage is the incidental signal loss from voltage-divider action.

Probe functions affect calibration

When the X10 low-cap function of a probe is selected, the signal at the scope input connector is divided by 10. Only 1/10 of the amplitude reaches the scope. This changes the V/div calibration of all vertical-sensitivity ranges.

Most scopes depend on the operator to move the decimal point one position to the right (1.2VPP becomes 12VPP, 98VPP becomes 980VPP etc). This becomes automatic with practice. However, it can cause errors.

Sencore's new model SC-60 and one older model have volts/division calibrations for the 10-times loss of signal. No mathematics is required. Several Tektronix scopes have calibrations (Figure 5) with a different

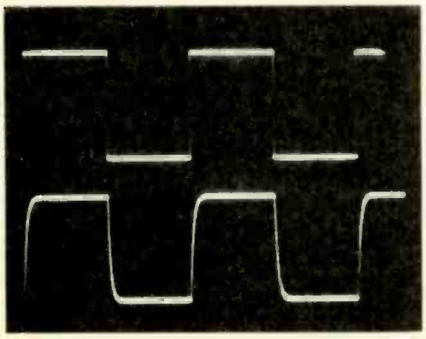


Figure 4 Direct of X1 scope probes can round edges of waveforms. Top trace shows the 16kHz squarewave from the generator when an X10 probe was connected. After the probe was changed to X1, the integration was evident in the slower rise and fall times and the rounded corners. The impedance was 11KΩ, which is common in video circuits.

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
Caywood Electronics, Cont.							
Millen 90902	No amplifier 90928 amplifier available 39V p-p per cm	.....	.....	.....	.....	.....	60Hz line sweep
Millen 90905-B	No amplifier 90928 amplifier available 12V p-p per cm	.....	.....	.....	.....	.....	60Hz line sweep
Millen 90925	0.16V peak to peak per cm	dc to 550kHz	.....	.....	.....	.....	2-30 kHz
EH International							
1060	2mV/div-10V/div	w/961 probe 1GHz bandwidth w/960 probe 350MHz bandwidth	350ps	.....	X	.....	0.2ns/div-100ms/div
Gould Inc., Instruments Division							
OS255	2mV/cm to 10mV/cm	15MHz	23ns	.....	X	.....	500ns-0.2s/cm
OS260	2mV/cm to 20V/cm	15MHz	23ns	.....	.....	X	500ns-0.2s/cm
OS1200	2mV/cm to 10V/cm	25MHz	14ns	X	X	.....	200ns/cm-1s/cm
OS1100A	1mV/cm to 10V/cm	30MHz	12ns	X	X	.....	200ns/cm-2s/cm
OS3500	2mV/cm to 5V/cm	60MHz	< 6ns	X	X	.....	50ns/cm-0.5s/cm
OS3600	2mV/cm to 5V/cm	100MHz	3.5ns	X	X	.....	50ns/cm-0.5s/cm
OS3350	1mV/cm to 20V/cm	40MHz	9ns	X	X	.....	100ns/cm-1s/cm

Horiz. Amp Band-width	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
.....	.....	.....	.....	.....	• 3½"x19" rack mount scope	18
.....	.....	.....	.....	.....	• 5" rack mount scope	
.....	.....	.....	.....	.....	• 2-5/8"x4-5/8" scope on 3½"x19" rack panel	
.....	.....	X	.....	.....	• Waveform analyzer digitizer • Digital readout sampling scope • Programmable	19
3dB at 1MHz, <3° at 50kHz	X5 (100ns) cm	.....	X	1V peak, 1kHz nominal sq. wave	• Sum & difference • X-Y display • Dc trigger • Z-modulation	20
3dB at 1.5MHz, <3° at 200kHz	X10 (50ns/cm)	.....	.....	1V peak, 1kHz nominal sq. wave	• True dual beam • Single sweep • X-Y-Y display • Dc trigger • Z-modulation	
3dB at 500kHz, <3° at 250kHz	X10 (20ns/cm)	.....	.....	1V peak, 1kHz nominal sq. wave	• Sum & difference • X-Y display • 6kV accelerating V • Dc trigger • Z-modulation	
3dB at 1MHz, <3° at 500kHz	X10 (20ns/cm)	X	.....	1V peak, 1kHz nominal sq. wave	• Sweep delay • Single sweep • 10kV acceler. V • Dc trigger • Z-modulation	
3dB at 1.5MHz, <3° at 500kHz	X10 (5ns/cm)	X	.....	1V peak, 1kHz nominal sq. wave	• Trigger view • 4-trace alternate • Trigger hold-off • Dc trigger • Z-modulation	
3dB at 1.5MHz, <3° at 500kHz	X10 (5ns/cm)	X	.....	1V peak, 1kHz nominal sq. wave	• X-Y-Y display • Δ time w/DMM optional signal amplitude w/probe	
3dB at 2MHz, <3° at 500kHz	X5 (20ns/cm)	X	X	1V peak, 1kHz nominal sq. wave	• Special TV waveform & raster monitor • Digital line callup for PAL or NTSC • Teletext compatible • LED display of line number • Also functions as conventional 40MHz dual trace scope	

Scope roundup

reference point for 1X and 10X modes.

Any of these systems can be used without errors if the operator understands how the 10X errors are corrected.

Dc and ac coupling

Scopes need flat frequency response down to dc. This prevents tilting of low-repetition-rate square waves and allows dc voltages (or the combined dc and ac signal) to be measured. Direct coupling is necessary in all scope vertical-amplifier stages for dc response.

The ability to measure dc voltages is valuable for many tests. However, examination of a small ac waveform riding on a large dc voltage is unsatisfactory (the waveform is too small, or it moves off screen). For those tests, the scope must show ac waveforms with all dc voltages removed. This is accomplished by switching in a 0.1μF capacitor between the scope input jack and the internal vertical amplifier stages.

A three-position switch (Figure 6) selects ac without dc voltages (AC position) or ac and dc voltages together (DC position). At first, the third (GND) position seems superfluous. Zero voltage can be obtained merely by removing a probe from the point being measured. In actual operation, however, the extra grounded switch position is helpful. Disconnection of the probe from the test point doesn't always remove all signal from the probe. Strong signals (such as pulses from horizontal-sweep systems) can often be picked up by a scope probe from

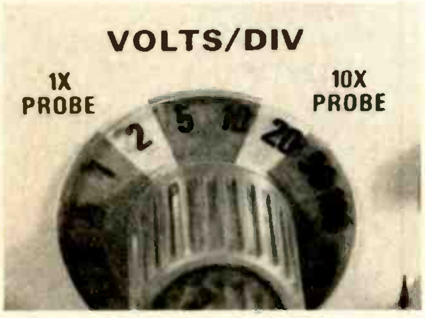


Figure 5 Some Tektronix scopes have two reference points for vertical-sensitivity switch positions. Two Sencore models show the volt/division value with an X10 probe, because it should be used for almost all measurements.

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
Gould, cont.							
OS4000	5mV/cm to 20V/cm	10MHz conventional	35ns	X	X	.....	1ns/cm-20s/cm
		450kHz digital storage	2MHz sample rate				
OS4100	100uV/cm to 5V/cm	250kHz digital storage	1MHz sample rate	X	X	.....	100μs/cm -50s/cm
Hickok							
515	5mV	15MHz	24ns	.....	.....	.....	0.2s/div to +0.1μs/div
517	5mV	15MHz	24ns	.....	X	.....	0.2s/div to 0.1μs/div
Hitachi							
V-151B	1X: 5mV/div	15MHz	24ns	.....	.....	.....	0.2μs/div
	5X: 1mV/div	5MHz	72ns				
V-152B	1X: 5mV/div	15MHz	24ns	.....	X	.....	0.2μs/div
	5X: 1mV/div	5MHz	72ns				
V-202	1X: 5mV/div	20MHz	17.5ns	.....	X	.....	0.2μs/div
	5X: 1mV/div	7MHz	50ns				
V-301	1X: 5mV/div	30MHz	24ns	X	.....	.....	0.2μs/div
	5X: 1mV/div	5MHz	72ns				
V-302B	1X: 5mV/div	30MHz	24ns	X	X	.....	0.2μs/div
	5X: 1mV/div	5MHz	72ns				
V-352	1X: 5mV/div	35MHz	17.5ns	X	X	.....	0.2μs/div
	5X: 1mV/div	7MHz	50ns				
V-550B	1X: 5mV/div	50MHz	7ns	X	X	.....	50ns/div
	5X: 1mV/div	10MHz	36ns				
V-059B	1X: 50mV/div	7MHz	50ns	.....	.....	.....	10μs/div
	5X: 10mV/div	2MHz	175ns				

Horiz. Amp Bandwidth	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
.....	X10 (100ns/cm)	Digital delay	.....	1V peak, 1kHz nominal sq. wave	• Digital storage plus 10MHz real time • Transient capture • Nonfade digital display • Waveform generation • Bus output • Selectable pretrigger viewing • X-Y, T-Y outputs	20
250kHz	X10 (10μs/cm)	Digital delay	.....	.....	• Digital storage in T-Y & X-Y modes • Bipolar trigger • Transient capture • Waveform generation • Bus output • Y-Y & T-Y outputs	
1MHz	X5	.....	X	X		21
1MHz	X5	.....	X	X		
500kHz	100ns/div (10X)	.....	X	1kHz square		22
500kHz	100μs/div (10X)	.....	X	1kHz square		
500kHz	100ns/div (10X)	.....	X	1kHz square	• Square CRT • Low drift	
500kHz	100ns/div (10X)	.....	X	1kHz square		
500kHz	100ns/div (10X)	.....	X	1kHz square		
500kHz	20ns (10X)	.....	X	1kHz square	• Square CRT • Low drift	
500kHz	5ns/div (10X)	X	X	1kHz square	• Trigger view • Auto focus • Variable holdoff	
10kHz	1μs/div	.....	X	Gate signal square	• Small size • Lightweight • Ac, dc or battery powered • TW waveform monitor	

Figure 6 New triggered scopes have some kind of three-position switch that blocks dc and passes ac to the vertical channel (AC), disconnects the probe and grounds the vertical-amplifier input to give zero input (GND) or passes both ac and dc to the vertical amplifier (DC).

several inches away. Occasionally, a true-zero signal is needed for reference but the probe is not easily accessible. The switch allows a rapid change from any waveform to zero volts.

Desirable scope bandwidth

It is difficult to specify a minimum scope vertical-amplifier frequency response. The low-frequency response should be flat to dc. But a satisfactory high-frequency response depends on the specific measurement.

Here are some examples:

- The limits of human hearing are about 16Hz to 20kHz. Therefore, audio sinewaves should require response only to 20kHz. However distortion might produce square waves, which need about 20 harmonics. A scope for audio should be flat within 3dB from 16Hz to 400kHz.
- Vertical-sweep pulses require about 100 harmonics for good waveform reproduction. Therefore, TV vertical sweep needs scope response to 6kHz.
- TV horizontal-sweep pulses also require 100 harmonics, or an upper response to 1.57MHz.
- Video signals without chroma have harmonics up to about 2.5MHz; video plus chrominance sidebands extends to about 4.1MHz. Chroma burst has a frequency of 3.58MHz and a sine waveshape.

According to these figures, a scope for TV servicing needs a bandwidth that is absolutely flat between dc and 4.1MHz. A good 5MHz scope apparently could fill all these needs.

Scope roundup

However, glitch and transient identification require at least twice the usual bandwidth, bringing the requirements to 10MHz.

Many new TV receivers include microprocessors and other digital devices. A 15MHz scope rounds the corners of these digital signals. So, the upper frequency response must be doubled again. Proper reproduction of digital glitches requires about 30MHz response.

Perhaps the response should be extended even more to satisfy demands in the future when the repetition rate of digital signals will be made faster.

These estimates of frequency response neglect an important practical factor: Usually, scopes with wider vertical response have corresponding faster sweep times. For example, popular 10MHz and 15MHz scopes of the past might have a shortest sweep time of 1µs, which can show no less than about 36 cycles of a 3.58MHz carrier. By contrast, a newer 35MHz scope has a shortest sweep time of 0.1µs, and it can show about 3.6 complete cycles of the same 3.58MHz carrier. (Figure 7). Switching in the X5 horizontal expansion can improve those specifications, but at the expense of decreased trace brightness and with a less stable wave-

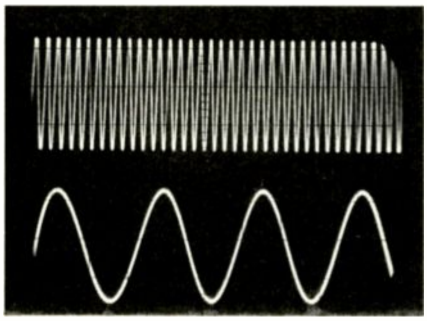


Figure 7 Minimum sweep time determines how few cycles of a high-frequency signal can be displayed. Waveshapes are difficult to analyze when more than two or three are seen. A scope with a 1µs shortest sweep time will display about 35 cycles of a 3.58MHz color carrier (top trace). Another scope having a fastest sweep time of 0.1µs can show about 3.5 cycles (lower trace). Of course, a 1 s scope can display the lower trace if it has 10X horizontal expansion, but the brightness will be decreased severely and instability might become a problem. By contrast, a 0.1µs scope with 10X expansion can show about 3.5 cycles at 35MHz.

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
Kikusui Electronics							
5650	1mV-5V	dc-50MHz	7ns	X	X	.....	.1µs-.5s
5630	1mV-5V	dc-35MHz	10ns	X	X	.....	.1µs-5s
5531	1mV-5V	dc-35MHz	10ns	X	X	.....	.....
5530	1mV-5V	dc-35MHz	10ns	X	X	.....	.2µs-.5s
5520	1mV-5V	dc-20MHz	17ns	.....	X	.....	.2µs-.5s
5513	1mV-5V	dc-10MHz	35ns	.....	X	.....	.1µs-.1s
Leader Instruments Corp.							
LBO-515B	5mV	30MHz	11.5ns	120ns	X	.....	.2µs/div -.5s/div
LBO-520A	5mV	35MHz	10ns	120ns	X	.....	0.2µs/div -0.5-5/cm
LBO-507A	10mV	20MHz	17.5ns	.....	.....	.....	0.5µs/cm -200ms/cm
LBO-508A	10mV	20MHz	17.5ns	.....	X	.....	0.5µs/cm -200ms/cm
LBO-513	1mV	10MHz	35ns	.....	.....	.....	0.5µs/cm -200ms/cm
LBO-514	1mV	10MHz	35ns	.....	X	.....	0.5µs/cm -200ms/cm
LBO-308S	2mV	20MHz	17.5ns	.....	X	.....	0.5µs/cm 0.2s/cm
LBO-517	1mV	50MHz	7ns	120ns	X	.....	0.05µs/cm 0.5s/cm
Non-Linear Systems							
MS-15	10mV/div	-3dB at 8MHz and -6dB at 15MHz	30ns	.....	.....	.....	.5s/div-.1µs/div
MS-215	10mV/div	-3dB at 8MHz and -6dB at 15MHz	30ns	.....	X	.....	.5s/div-.1µs/div
MS-230	10mV/div	-3dB at 30MHz	15ns	.....	X	.....	.1s/div-.05µs/div

Horiz. Amp Band-width	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
dc-2MHz	10X	X	X	X	• Portable • Triggered delayed sweep • 500kHz chop freq. • Auto-trigger level • Auto-focus • Variable holdoff	24
dc-2MHz	10X	X	X	X	• Portable • Triggered delayed sweep • 500kHz chop freq. • Auto-trigger level • Auto-focus • Variable holdoff	
dc-2MHz	5X	X	X	X	• Triggered delayed sweep • Variable holdoff • Portable	
dc-2MHz	5X	.....	.....	X	• Portable • Single sweep	
ac-1MHz	5X	.....	X	X	• One touch X-Y • Single sweep • ac or dc triggering • Bench unit	
dc-1MHz	5X	.....	X	X	• Bench unit	
1MHz	X	X X10	X	X	• Calibrated delayed time base	25
1MHz	X X10	.....	X	X	• Internal graticule Rectangular CRT	
250kHz	X X5	.....	X	X		
800kHz	X X5	.....	X	X		
250kHz	X X5	.....	X	X	• High sensitivity	
800kHz	X X5	.....	X	X		
1MHz	X X5	.....	X	X	• Portable, battery operable, 10 lbs.	
1MHz	X X10	X	X	X	• 3rd & 4th chan. trig. view • Alternate triggering • Alternate time base display	
.....	.....	.....	.....	1V sq. wave	• Small size • Portable • Battery-powered • Lightweight	26
.....	.....	.....	.....	1V sq. wave	• Small size • Portable • Battery-powered • Lightweight	
.....	.....	.....	.....	1V sq. wave	• Small size • Portable • Battery-powered • Lightweight	

form. Save the X5 feature for emergencies; don't depend on it for daily routine tasks.

Dual-trace operation

Both dual-beam and dual-trace scopes can show two separate waveforms on one CRT screen. Dual-beam types have the equivalent of two scopes in one envelope. Advantages are full brightness of both traces and absolutely the same phase of the two waveforms. Dual-beam models are rare and cost more than dual-trace models. Both require two identical sets of vertical amplifiers.

The majority of scopes purchased by the industrial and home-entertainment electronic fields are dual-trace models. There are too many advantages of dual trace to list them all. One obvious and helpful application is comparing the same signal at various points of the circuit. Another is the ability to compare the phase of certain signals as they undergo waveform and amplitude changes.

A few scope models offer separate triggering of each channel independently. This is helpful for asynchronous operation with signals of slightly different frequencies, but it has limited value in TV servicing.

Vertical-signal delay

Top-of-the-line scopes often have two delays. One is horizontal-sweep delay in which a second timed sweep is initiated at a selected point of the regular sweep; this expands certain sections of a waveform. The other type delays the vertical-channel scope signal. It is needed because the horizontal sweep is triggered from a selected voltage level of the vertical-channel signal. However, a small amount of time is required before the horizontal sweep begins to move the CRT beam. During this time interval, the vertical signal has moved on without being seen on the screen. The tiny section of vertical signal occurring between initiation of triggering and the actual beginning of horizontal sweep is lost.

There is no problem when the signal is a sinewave. The scope-triggering level control is offset slightly so the missing section is not noticed. Problems arise when viewing fast-rise-time fast-repetition pulses or squarewaves. The time is so short during the fast rise or fall

Scope roundup

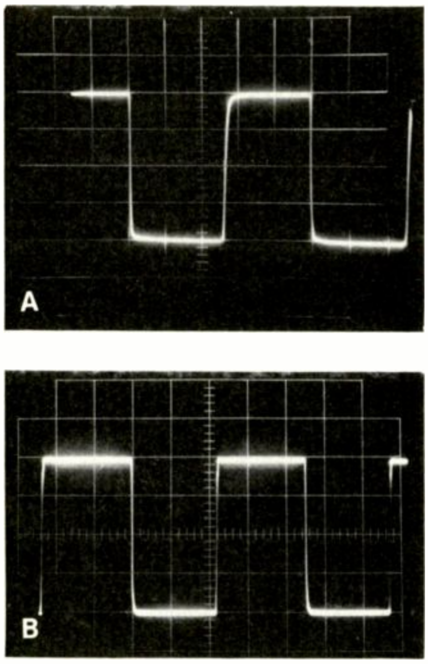


Figure 8 A signal-delay line in a scope vertical channel prevents loss of the leading edge of fast rise-time pulses and squarewaves: (A) A 15MHz scope without signal delay was missing about a third of the first peak, and the waveform showed rounded corners and slower rise and fall times of the 100kHz squarewave; and (B) A 35MHz scope with an internal signal-delay line displayed all of the first leading edge and the waveshape was better.

of the waveform that, even if triggering was initiated at the bottom of a positive pulse (for example), the leading edge would be finished before any trace could begin. The visible result is elimination of the initial leading or falling edge (whichever triggered the sweep). Fast-repetition-rate signals also lose part of the first peak (Figure 8). At 100kHz, about one-third is missing.

A delay line (coaxial cable or transmission line) in each vertical channel slows movement of the vertical signal toward the CRT. When the artificial delay is correctly designed to be equal to the inherent delay of the horizontal sweep, the triggering point of the vertical arrives at the CRT exactly in step with the beginning of horizontal sweep. Therefore, none of the vertical waveform is lost.

Horizontal-sweep times

Horizontal sweep in a triggered scope is initiated by arrival of a

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
Norland Corporation							
3001 Processing Digital	±100mV-±100V	.....	.....	.....	4-trace	.....	time/sample 2μs per sample (max)
Philips Test & Measuring Instruments							
PM 3207	5mV-10mV	0-15MHz	23ns	.....	X	.....	.2s/div 500ns/div
PM 3212	2mV-10V	0-25MHz	14ns	X	X	.....	.5s-200ns
PM 3214	2mV-10V	0-25MHz	14ns	X	X	.....	.5s-200ns
PM 3216	2mV-10V	0-35MHz	10ns	X	X	.....	.5s-100ns
PM 3218	2mV-10V	0-35MHz	10nS	X	X	.....	.5s-100ns
PM 3226	2mV-10V	0-15MHz	23ns	.....	X	.....	.2s-500ns
PM 3233	2mV-10V	0-10MHz	35ns	X	.....	X	.5s-200ns
PM 3234	2mV-10V	0-10MHz	35ns	X	.....	X	.5s-200ns
PM 3244	5mV-2V	0-50MHz	7ns	X	4 ch.	.....	.5s-50ns
PM 3262	2mV (35MHz) -5V	0-100MHz	3.5ns	X	X	.....	1s-50ns
PM 3263	2mV (35MHz) -5V	0-100MHz	3.5ns	X	X	.....	1s-50ns
PM 3264	2mV (35MHz) -5V	0-100MHz	3.5ns	X	4 ch.	.....	1s-50ns
PM 3266	2mV-5V	0-100MHz	3.5ns	X	X	.....	1s-50ns

Horiz. Amp Band-width	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
.....	.....	Delayed trigger pre/post trigger	.....	X	• Programmable • Mathematical processing • RS232 and IEEE interacting	27
0-2MHz	X5 100ns	.....	X	X	• Chan B invert • Add mode • Double insulated	28
0-1MHz	X10 20ns	.....	X	X	• Composite triggering • Double insulated • 10kV CRT	
0-1MHz	X10 20ns	X	X	X	• Comp. trig. • 10kV CRT • Double insulated • Alternating timebase display	
0-1MHz	X10 10ns	.....	X	X	• Comp. trig. • 10kV CRT • Double insulated • Trigger holdoff	
0-1MHz	X10	X	X	X	• Comp. trig. • 10kV vert • Trigger holdoff • Alternating time-base	
0-500kHz	X5 100ns	.....	X	X	• Compact size	
0-1MHz	X5 40ns	.....	X	X	• 10kV dual-beam CRT	
0-1MHz	X5 40ns	.....	X	X	• Variable resistance storage	
0-1MHz	X5 10ns	X	.....	X	• 4-channel scope	
0-2MHz	X10 5ns	X	.....	X	• Composite trig. • Trigger holdoff • Trigger view 3rd ch. • Alternating time-base	
0-2MHz	X10 5ns	X	.....	X	• Comp. trig. • Trig. holdoff • Trig. view 3rd ch. • Alternationg time-base • Microprocessor controlled timing	
0-2MHz	X10 5ns	X	.....	X	• Four channel • Trig. holdoff • Trig. view 5th channel • Comp. trig. - alt. TB	
0-2MHz	X10	X	.....	X	• Variable resistance storage • Comp trigger	
					• Comp. trigger • Trigger holdoff • Trig. view • Alternating	

Scope roundup

certain predetermined voltage level in the vertical signal. This is called *triggering*. The precise signal voltage that causes triggering is selected by adjustment of controls and switches.

After triggering has occurred, the horizontal-sweep circuit moves the CRT beam across the screen. However, the *time* required for the beam to move from the left edge to the right edge of the screen is determined by other time-constant circuits. Sweep can be adjusted with time/division controls to occur over a period of minutes or for as little as a fraction of a microsecond.

The CRT screen exhibits whatever segment of the signal occurs during the time required by the horizontal sweep. A thousand cycles of the signal might be shown, or a fraction of one cycle. It depends on the sweep time versus the time of each signal cycle.

After the sweep is finished, the sweep circuit stops completely and waits until it is forced to sweep again by another triggering. In turn, triggering is initiated again when the selected voltage next arrives in the vertical signal. Of course, every triggering is followed by horizontal sweep for the selected time, and the sweep then waits until the next triggering voltage appears in the vertical signal.

Horizontal sweep requires two separately controlled steps: (1) triggering according to a selected signal voltage; and (2) horizontal deflection for a controllable length of time.

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
Sencore							
SC60	5mV/div	-3dB 60MHz -12dB 100MHz	6ns	X	X	.....	100ms through .1μs 19 steps
Simpson							
452	5mV/cm	dc to 15MHz	24ns	.....	X	.....	0.2μs/cm to 0.5s/cm
454	5mV/div	dc to 15MHz	24ns	.....	X	.....	0.5μs/div to 0.5s/div
Tektronix							
T912	2mV/div	dc-10MHz	.....	X	X	.....	0.5μs/div
T921	2mV/div	dc-15MHz	.....	X	.....	.....	0.2μs/div
T922	2mV/div	dc-15MHz	.....	X	X	.....	0.2μs/div
T932A	2mV/div	dc-35MHz	.....	X	X	.....	0.1μs/div
T934A	2mV/div	dc-35MHz	.....	X	X	.....	0.1μs/div
314	1mV/div	dc-10MHz	.....	.....	X	.....	0.1μs/div
335	1mV/div	dc-35MHz	.....	.....	X	.....	0.02μs/div
434	10mV/div	dc-25MHz	.....	.....	X	.....	0.02μs/
455	5mV/div	dc-50MHz	.....	.....	X	.....	0.05μs/div

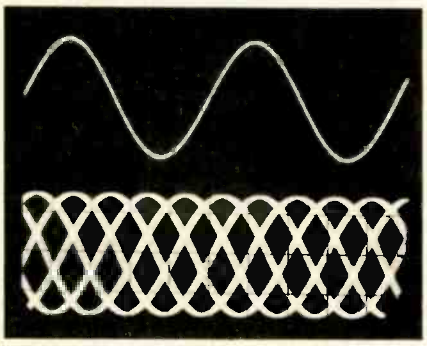


Figure 9 The normal action of a triggered scope is to show a trace with waveform only when properly triggered. Otherwise, the screen shows nothing. When a scope has some variation of automatic triggering, it has a normal waveform when triggered correctly (top trace) and an unstable unlocked waveform when not triggered. Without an input signal, the auto feature supplies a base line.

Unlike recurrent sweep scopes, triggered scopes have no oscillator (unless they include an automatic feature described later). In the absence of a vertical signal, triggering cannot occur and there is no horizontal sweep.

The sweep time required to display two cycles of any waveform is easy to calculate (of course, in practice the sweep time can be varied until the two-cycle display is obtained). Each cycle takes a certain amount of time, and two cycles double the time (which is the total of ten graticule divisions). Each division is given the time indicated by the time/division switch.

Therefore, the time/division switch should be turned to 1/5 of the time required for one cycle of the waveform. The time of one cycle is obtained by taking the reciprocal of the frequency (one divided by the frequency).

For a 20Hz sinewave display, for example, the time of one cycle equals 1/20 (0.05 seconds or 50 milleseconds). The time/div switch then should be set for 1/5 of 50ms (10ms) to produce two cycles on the CRT.

Audio measurements seldom are required below 20Hz, and the 10ms/div time will provide about six video vertical-interval fields. Therefore, *for TV and audio servicing there should be no need for scope sweeps longer than 10ms/division.* Most new scopes provide 200ms/div or longer. Some models have 0.5s/div for the longest time;

Horiz. Amp Band-width	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
5MHz less than 3° phase shift 10MHz usable	10X	.....	X	1UP-P 2kHz square wave	• 2kV probes • TVV & TVH preset buttons • Timebase switch calibrated in time and freq.	29
.....	X5	.....	X	X		30
.....	X5	.....	X	X		
.....	X10	X	X	X		31
.....	X10	X	X	X		
.....	X10	X	X	X	• Dual-trace • Rack mount available	
.....	X10	X	X	X	• Delayed sweep and differential	
.....	X10	X	X	X	• Variable trigger holdoff and differential	
.....	.....	X	.....	.....	• Battery-operated • Weighs 10.5 lbs.	
.....	.....	X	.....	.....	• Battery-operated • Weighs 10.5 lbs.	
.....	.....	.....	.....	.....	• Split-screen storage	
.....	.....	X	.....	.....	• Cost-effective for 50MHz bandwidth	

that requires five seconds for one sweep. These are more slow sweep choices than are needed for anything except medical measurements and subsonic audio. The variety is more than adequate.

The same calculations are used to determine what sweep times are needed to show two cycles of high frequencies, such as several megahertz.

For example, 1MHz requires 1μs for one cycle, so the time/div switch must be adjusted for 0.2μs. Color-carrier 3.58MHz frequency must have 0.056μs time/div setting. And a sweep of only 0.02μs (20ns) is necessary to display two cycles of 10MHz. A scope with a shortest time of 0.1μs and an X5 magnifier has the equivalent of a 20ns sweep, or another scope with 0.1μs plus an X10 magnifier provides the equivalent sweep of 10ns/div (giving two cycles at 20MHz). Of course, many waveforms can be examined fairly well with more than two cycles displayed. In that way, a 0.1μs sweep with an X10 magnifier can display six cycles of 60MHz.

New scopes have short sweep times that are more than adequate for color TV servicing. For radio communications, a 0.1μs sweep plus 5X or 10X magnifier is adequate up to 30MHz and 60MHz, respectively.

Automatic sweep

Many new scopes have switch positions that allow a choice of normal triggering or a type of automatic triggering. In the *normal* triggering mode, correct triggering produces a stable stationary waveform; failure to trigger prevents display of any line or waveform. The loss of all light on the screen raises questions about many scope adjustments.

In *auto-triggering* mode, correct triggering again displays a stable stationary waveform; failure to trigger produces a waveform of the correct height but scrambled so it resembles an unlocked recurrent-scope trace. When triggering is not occurring regularly, the circuit becomes an uncontrolled oscillator that gives horizontal deflection. The frequency is affected slightly by adjustments of the time/div variable control, but it will never lock to the vertical signal.

The auto-triggering feature is a convenience for the scope operator, because the free-running unlocked waveform proves all conditions (except triggering) are normal.

Expanded waveforms

Triggered scopes can expand waveforms horizontally in three ways:

- by switching to a shorter horizontal-sweep time;
- by a second shorter-time horizontal sweep. A small section of the conventional waveform is selected and then expanded to fill the screen. Usually, this is called delayed sweep, but it should not be confused with vertical-signal delay (previously described), which has a different purpose; and
- by increasing the trace width when a 5X or 10X switch is activated. A few scopes have controls for variable width increases.

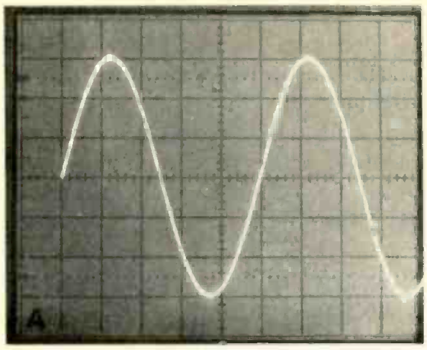
All three methods of horizontal expansion (magnification) have advantages and disadvantages.

TV/video sync separator

All scopes have great difficulty in triggering properly from composite video. In fact, it is almost impossible to obtain stable TV vertical-rate waveforms. The problem is solved satisfactorily in scopes that have an internal TV-type sync separator. A *video* or *horizontal video* and *vertical video* position of the triggering-selector switch allows triggering from the video sync rather than from the composite-video waveform.

This internal sync separator provides stable video waveforms, and it is essential for servicing all television and video products (tape and disc). Also, complex waveforms having repetition rates similar to those of television vertical and horizontal rates can often be trig-

Scope roundup



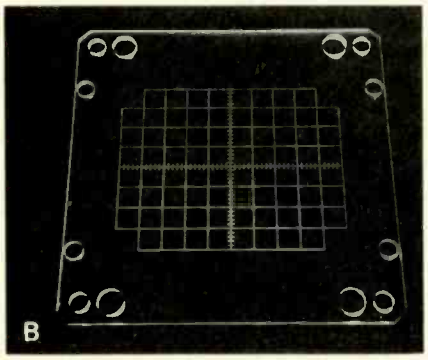


Figure 10 Only an internal graticule applied to the inside of the CRT faceplate (photograph A) can prevent parallax errors. When the lines are engraved into a separate piece of plastic (photograph B), the measurement changes according to the operator's viewing angle. This error can approach 10% in extreme cases.

gered with good stability by use of the internal sync separator.

Calibration waveform

Many scopes have a calibration squarewave signal available from a front-panel jack. The waveform is useful for checking the vertical-sensitivity calibrations, and it is essential for the adjustment of low-capacitance probes.

Other features

In most scopes, the calibration lines and divisions are engraved on clear plastic (Figure 10). The waveform appears on the inside of the CRT faceplate, and the plastic graticule is placed in front of the faceplate. A sizeable distance separates the engraved calibration lines and the actual waveform. This can cause serious errors from parallax. If the graticule could be observed from an infinite distance, there would be no problem. But the errors increase as the viewer ap-

Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.
Telequipment							
1010	5mV/cm	dc-10MHz	35ns	.....	X	.....	200ns/cm to 0.2s/cm
1011	1mV/cm-20V/cm	dc-10MHz	35ns	.....	X	.....	200ns/cm to 0.2s/cm
1015	5mV/cm	dc-15MHz	23ns	.....	X	.....	200ns/cm to 0.2s/cm
1016	1mV/cm to 20V/cm	dc-15MHz	23ns	.....	X	.....	200ns/cm to 0.2s/cm
D66A	1mV/cm to 50V/cm	dc-25MHz	14ns	X	X	.....	100ns/cm to 2s/cm
D67A	1mV/cm to 50V/cm	dc-25MHz	14ns	.....	X	.....	200ns/cm to 2s/cm
S22	1mV-5V/div	dc-5MHz	70ns	.....	X	.....	1μs-0.3s/div
D32	10mV-5V/div	dc-10MHz	35ns	.....	X	.....	0.5μs-0.5s/div
D34	2mV-5V/div	dc-15MHz	23ns	X	X	.....	0.2μs-0.5s/div
DM64	1mV-50V/cm	dc-10MHz	35ns	.....	X	.....	100ns/cm 2s/cm
SM1	5mV-20V/cm	dc-5MHz	70ns	.....	.....	.....	1μs-0.5s/div
Vu-data Corporation							
2521	5mV/div	25MHz	14ns	X	X	.....	100ns
PS-950A	5mV/div	50MHz	7ns	X	X	.....	100ns
PS-935A	5mV/div	35MHz	10ns	X	X	.....	100ns
2522	5mV/div	25MHz	14ns	X	X	.....	100ns
VIZ							
WO-527A	10mV/cm	dc-15MHz	23ns	.....	.....	.....	0.5μs/cm to 0.5s/cm
WO-555	10mV/cm to 20V/cm	dc-15MHz	23ns	X	.....	.....	0.5μs/cm to 0.5s/cm
Wavetek							
1901C	1mV/div	dc to 15kHz	.....	.....	.....	.....	.....
1903	150mV/div	dc to 15kHz	.....	.....	.....	.....	.....
1910	1mV/div	dc to 15kHz	.....	.....	X	.....	.....

Horiz. Amp Band-width	Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader Service Number
.....	X5	.....	X	X	• Beam locate • Trace locate	32
.....	X5	.....	X	X	• Ch. 1 & Ch. 2/ • Ch. 1 - Ch. 2 xy • Beam locate	
.....	X5	.....	X	X	• Beam locate • Trace locate	
.....	X5	.....	X	X	• Ch. 1 & Ch. 2/ • Ch. 1-Ch. 2 xy • Beam locate	
.....	X5	.....	X	X	• xy • Add & invert Ch. 2 • Chop/Alt • Single shot	
.....	X5	X	X	X	• Add & invert Ch. 2 • Chop/alt • Single shot	
.....	X10	.....	X	X	• Battery-operated	
.....	X5	.....	X	X	• Rechargeable	
.....	X5	.....	X	X	• Portable	
.....	X5	.....	X	X	• Storage • xy • Add & invert • Single shot	
.....	.....	.....	X	X		
200kHz	20ns/div	.....	.....	4V 1kHz	• Optional DMM-counter	47
200kHz	10ns/div	.....	.....	4V 1kHz	• Optional DMM-counter	
200kHz	10ns/div	.....	.....	4V 1kHz	• Optional DMM-counter	
200kHz	20ns/div	X	.....	4V 1kHz	• Digital delayed sweep and event count	
dc-1MHz	X10	.....	X	X	• TV line selector trigger polarity indicator	48
dc-1MHz	X10	X	X	X	• TV line selector trigger polarity indicator	
dc to 1.5kHz	.....	.....	.....	.....		49
dc to 15kHz	.....	.....	.....	.....		
dc to 1.5kHz	.....	.....	.....	.....		

proaches the graticule. At a distance of 6 or 8 inches, the error can be about one division at the top and another division at the bottom of the graticule. Errors at the sides are worse because the calibrated area is rectangular.

The solution for graticule parallax errors is a scope CRT with internal calibrations, usually called *internal graticule.* As the need for improved accuracy increases, it is hoped more manufacturers will offer this valuable feature.

A push on a *beamfinder* button compresses any waveform into a small area near the CRT screen's center. The feature is helpful in cases in which miscentering or excessive height (especially with pulses and squarewaves) has moved the waveform off the CRT screen.

Single-sweep describes a system for capturing transients. The controls are adjusted so that only the transient can produce triggering, and the scope then has no trace until the transient occurs. Another use is to reveal ultra-low-frequency wave shapes. Waveforms obtained by these methods are best studied from photographs taken with a scope-mounted camera.

CRT anode dc voltages range from 2kV to 12kV, according to model. Higher anode voltage provides increased brightness of trace and, to a lesser degree, allows sharper focus. Post-acceleration deflection (PDA) CRT construction also allows increased brightness.

A trace-rotation control allows the base line to be adjusted level to the graticule lines. This is accomplished by applying a magnetic field to the scope so it cancels the earth's magnetic field. Otherwise, the scope base line will tilt when the scope position is changed.

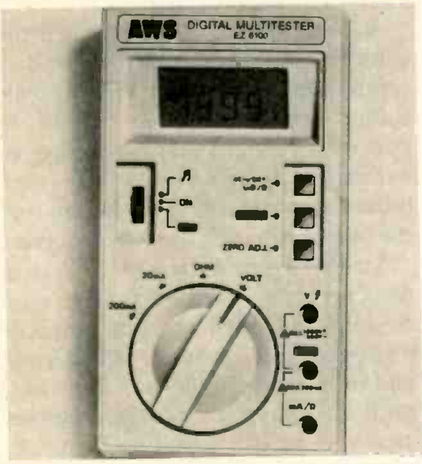
Storage scopes can retain a waveform after the signal has passed. One type of storage is done by special meshes in the CRT. Digital storage is another kind becoming important. A limitation of digital storage has been the restricted high-frequency response. Tektronix has a new model that can digitally store up to 10MHz.

Certain scope models have provision for line-power operation and external battery-pack or internal rechargeable-battery operation. This feature has great value for portable or mobile operation away from ac power. □

test equipment report

VOmA digital multimeter

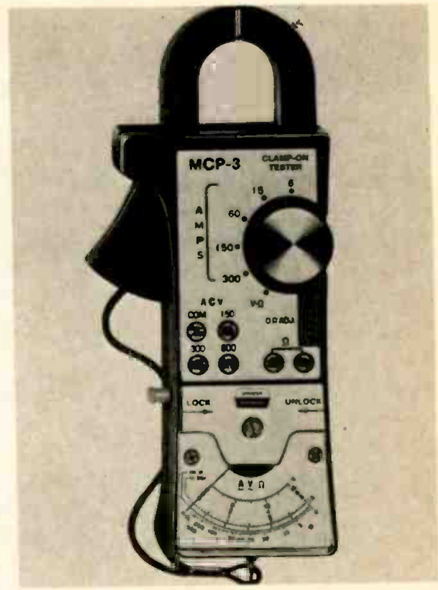
A.W. Sperry has introduced a new line of digital VOmA multimeters, the EZ Series. Two initial models, EZ-6100 and EZ-6200, feature full autoranging on volts and ohms, 3½-digit LCD display with 10mm high numerals, automatic indication of units and signs, autopolarity, overrange indication, low battery warning, audio tone continuity indication, regular and low power ohm ranges and range hold. Two 1.5V AA batteries give 200 hours of continuous use. The unit includes safety test leads and a special clip for one-hand lead operation, batteries, fuse and one spare. Carrying case is optional.



Circle (33) on Reply Card

Amp/volt/ohmmeter

Universal Enterprise's MCP3 clamp-on amp/volt/ohm meter locks in the measurement reading with a meter locking button. The MCP3 features a jaw width capacity of 1-1/8-inch, fuse protected ohm circuit, three color coded front panel and scale plate, and a 1-year warranty. The unit has five amperage ranges, three ac voltage ranges and a 0-1000 ohms range.



The MCP3 comes complete with

carrying case, test leads, batteries and an instruction manual at a suggested trade price of $54.95. Optional accessories include the ALS1 line splitter/multiplier and insulated alligator clip adaptors.

Circle (34) on Reply Card

5½-digit DMM

Data Precision has introduced the model 3600 5½-digit *field-expandable* DMM. The microcomputer-based instrument is housed in a half-rack width metal case and is

equipped to measure both dc voltage and dc voltage ratios. Additional measurement functions, including resistance and ac voltage, and digital interface/control, are available.

Circle (35) on Reply Card

Digital multitester

Universal Engerprises' DM100 provides fast, accurate test information with measurements displayed

on an easy to read .5-inch LED display. Basic accuracy is ±0.1%. Features of the 25-range DM100 include a battery test switch, automatic polarity to eliminate lead changing, auto-zeroing, protected OHM circuit and rugged construction for use in the field.

Circle (36) on Reply Card

Universal counter

The model 7000 5Hz-80MHz universal counter by **Triplett** utilizes a microprocessor-controlled reciprocal counting scheme. The unit features high resolution 5Hz-80MHz frequency measurement and totalize (event) counting to 1 billion and elapsed time measurement from 100μs to 100 hours. The model 7000's microprocessor/ROM automatically rounds off the display

while continuing to count each event.

The unit is housed in a high-impact thermoplastic case with carrying handle. It operates on standard 115Vac, 60Hz (230Vac with internal transformer jumpers) furnished complete with detachable 3-wire power cord and coax cable input lead. A rear panel accessory lead for input to an external (TTL or contact closure compatible) count gate is also provided.

Circle (37) on Reply Card

150MHz counter/timer

A 150MHz multi-function counter/timer, model 5845, has been introduced by **Data Precision.** The instrument measures frequency, period, period average, elapsed time, and event counting/totalizing. In addition to measuring sinewave frequency, it measures and resolves pulses occurring as close as 15ns apart. With the digital input/output option, the unit can be remote controlled and will output full measurement and status data. A field-installable input/output option is available.

The cost of the basic instrument is $325.

Circle (38) on Reply Card □

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