TEKSCOPE

NOVEMBER 1971

Tektronix and the World of Television Measurements

Using the 144 as a Simple Special Effects Generator

Measuring Distortions in the Television Signal

A Quick-Cal Procedure for the 520 Vectorscope

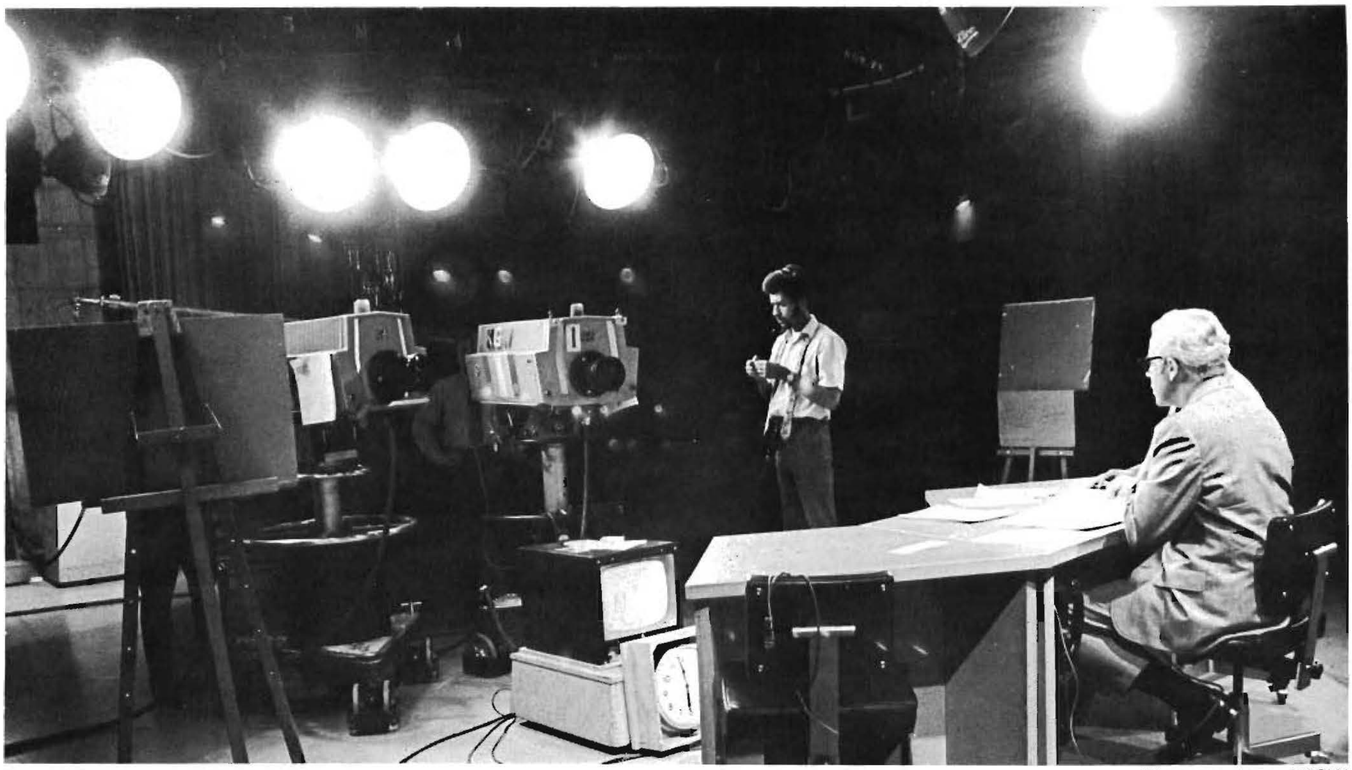


Photo courtesy of KGW

Tektronix and the World of Television Measurements

by Stephen D. Kerman
Manager of Television Product Market Development

Cover: Two new TEKTRONIX picture monitors are featured on the cover. The display on the center 650 Color Picture Monitor is called "Pulse Cross" and is used for on-the-air testing by the broadcaster. The 630 is a monochrome picture monitor.

From Swiss Chalet to a flat in London to a split-level home in Suburbia USA, one common scene is the family watching television. The languages are different, the systems by which color television is transmitted are different, but today hundreds of millions of people are accustomed to viewing in their own home, scenes from the moon and around the world, live and in color.

TEKTRONIX television instruments, waveform monitors, vectorscopes, test, transmission and synchronizing generators, and picture monitors will be found at almost every point in the television broadcasting system.

In addition to manufacturing television measurement products used in nearly every country in the world, Tektronix, Inc. plays an active part within the television engineering community developing measurements and techniques that help make the 25-inch color picture in your home a reality.

There are three color television systems in use around the world. The U.S. system, N.T.S.C. was the first system in regular use. The National Television Systems Committee developed the system which was put into regular use in the early 1950's. The NTSC signal adds a phase modulated subcarrier frequency to the rather predictable monochrome signal. In the U.S., this signal is an analog of scene brightness (luminance) one volt in amplitude. Each horizontal line in the U.S. is 63.5 microseconds long. During the first 11 microseconds, a synchronizing pulse and a reference burst of the color subcarrier occur to keep the system in step.

In Europe the PAL, or Phase Alternate Line system, is in wide use. Similar to NTSC in that there is a phase modulated subcarrier on the luminance signal, PAL has one major advantage over the U.S. system. The phase of the reference burst alternates on succeeding lines of the television picture. By comparing phase errors on succeeding lines which, by the nature of PAL, are equal but opposite, these errors may be nulled out and cancelled.

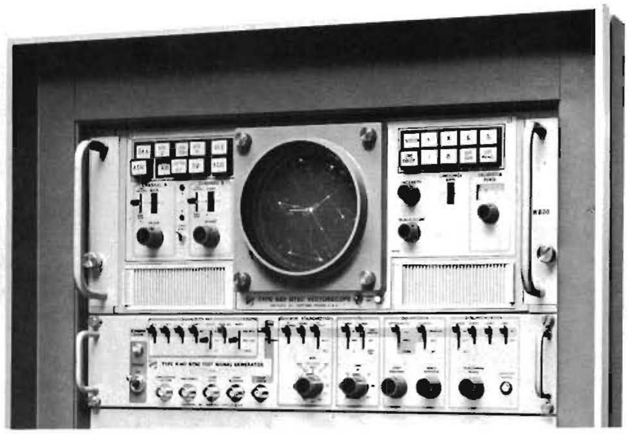
In France, Russia and many eastern European countries, SECAM, the French color system is in use. SECAM uses a frequency modulated subcarrier as its color transmission medium. SECAM receivers are the simplest of the three systems as neither chroma nor hue controls are needed.

Irrespective of the system in use, the television system must have synchronizing equipment. At this most important place in the system one finds the first of the TEKTRONIX television products. At present there are TEKTRONIX sync generators for European PAL (141A), South American PAL (142) and NTSC (140, 144, 146). These generators also include test signals for system checkout which we will discuss later. Use of the 144 to provide a special effects horizontal wipe function is described in the Teknique section of this issue. All of the generators derive the signals by digital means and represent the state-of-the-art in reliability, so important when the whole television system depends on these signals.

In addition to synchronizing and reference color burst signals, the television video signal contains information on scene brightness called "luminance" and scene color called "chrominance". Chrominance has two components, hue and saturation, which are represented by the phase and amplitude of the chrominance subcarrier. The video signal must be processed many times before it appears on the kinescope of your home TV set. It is sent by cable, microwave and satellite transmission and is eventually radiated by your local television station. Subscribers to community antenna systems (CATV) receive signals after further processing. Considering the gyrations the television signals undergo, it is remarkable that we see pictures at all. We like to think that Tektronix helps to make this possible.

Let's follow the picture from its creation in the studio and define some of the parameters to be measured and the instruments used to make these measurements. Details on the test signals and the measurements are found elsewhere in this issue. The live or film (telecine) television camera optically splits the light reflected by the scene into the three primary colors, red, green, and blue. These primary color components are converted into individual electrical video signals and then, in the camera control unit, the first of many measurements is made. The signal level (brightness) and balance between the three primary signals is measured and adjusted using a waveform monitor.

The waveform monitor is similar to a conventional wide band oscilloscope. The major differences are in triggering, sweep speeds and vertical amplifier response. Waveform monitors trigger on either the line or field sync information.



The TEKTRONIX 520 Vectorscope and 140 NTSC Signal Generator play a vital role in color broadcasting.

The sweep speeds are selected to display one or two lines or fields of information. Magnifiers permit close examination of small portions of these signals. Digital as well as variable delay permit rapid, accurate selection of discrete lines which, as you will see later, may contain test signals.

The vertical response of the waveform monitor must be very flat within the 6 MHz video band. It is usually within 1%. To accomplish this waveform monitors have a -3db bandwidth of about 18 MHz. Special filters are also available to limit response. A notch filter at the color subcarrier frequency enables viewing of the chrominance information only. A high pass filter permits measurement of differential gain with the waveform monitor. Differential gain is the amplitude change of the color subcarrier signal component as it changes from a low (black) to high (white) luminance level. The modulated staircase test signal is used to make this measurement.

From the camera control unit, the signals pass to an encoder where the three primary color video signals are encoded into a single signal of the system in use (NTSC, PAL, or SECAM). A second TEKTRONIX instrument, the vectorscope, may now be used to check the encoding process. The vectorscope is an X-Y oscilloscope which displays the chrominance component of an encoded video signal. The display of vectors shows both hue and saturation and may be used to accurately set up encoders and other signal processing equipment. The vectorscope is also used to match the relative phase of two color signals. Since it is phase sensitive, it is used to measure differential phase. Differential phase is the change in the phase of the color subcarrier signal as it changes from a low (black) to high (white) luminance level. Like the waveform monitor, the vectorscope can display discrete lines in the vertical interval to make in-service tests. Vectorscopes also make differential gain measurements as well as measurements of luminance cross-modulation.

Video tape recorders provide another source of program material. These complex machines use waveform monitors as well as vectorscopes for signal analysis. In addition to video signal processing, VTR's must provide the operator with information on the electromechanical operation of the machine. Servo control, head switching and other related signals are monitored by special oscilloscopes. One VTR manufacturer uses a modified waveform monitor to

TEKTRONIX Waveform Monitors are an integral part of these broadcast video tape recorders. Photo courtesy of KGW

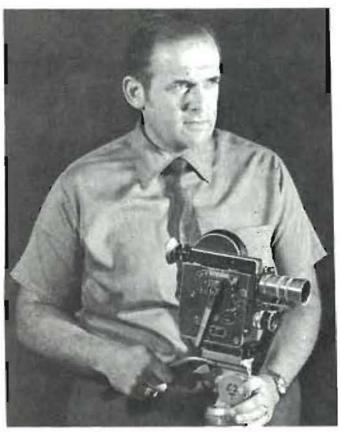
display these signals. A second manufacturer uses a TEKTRONIX X-Y display unit with a companion waveform monitor.

We have not mentioned pictures in this discussion of the television system. Even though test signals are important measurement tools, the picture is the end product and is all-important. Television picture monitors used by broadcasters have several features not found in home television sets. They must be very linear and have high bandwidth and resolution to accurately display the picture. Picture monitors should also have some measurement capability. Quality picture monitors must have standard phosphor colors so that they match each other and their reliability and ease of calibration cannot be overstressed.

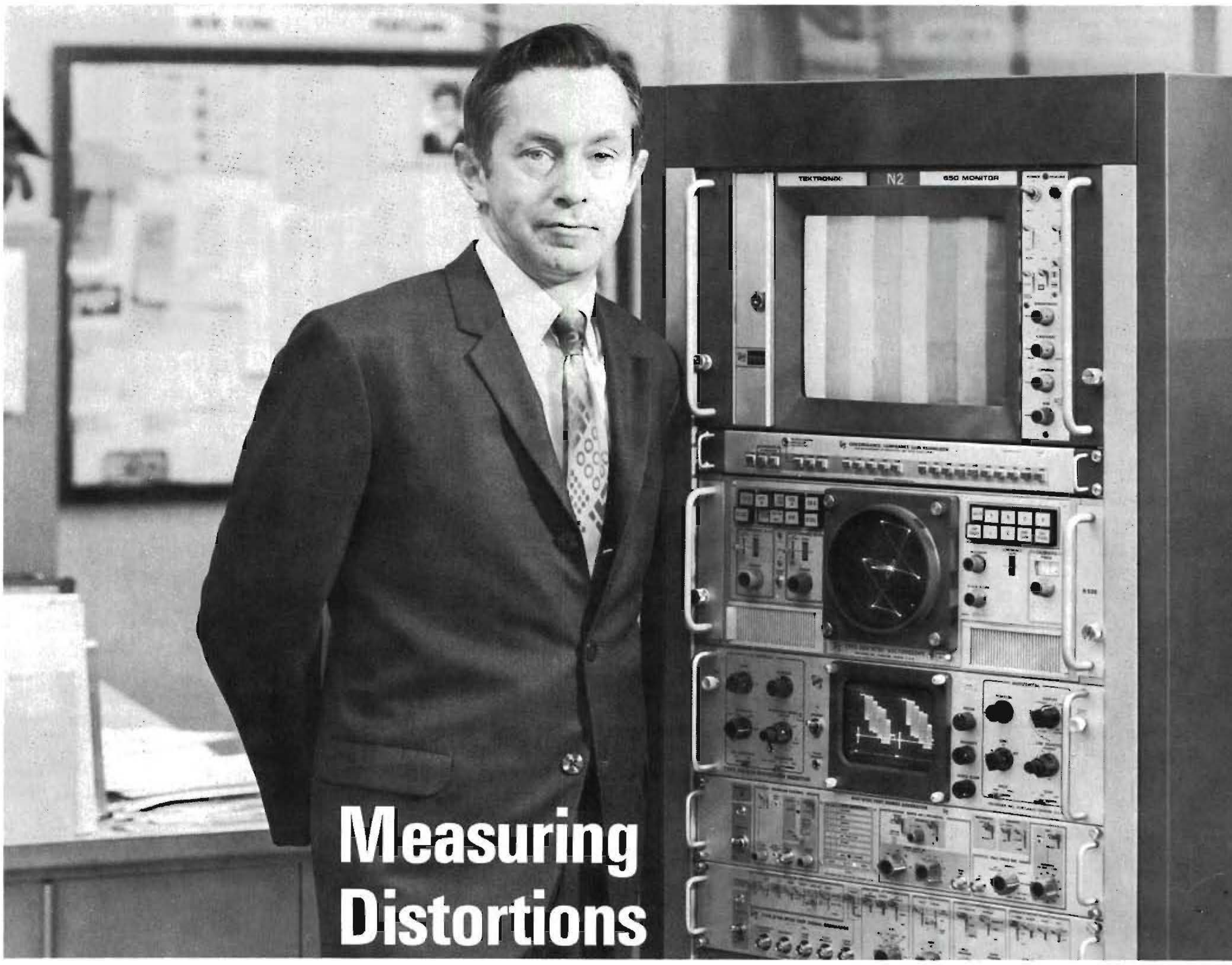
Tektronix Inc. has recently introduced both monochrome and color picture monitors which meet these criteria. The 650 family of color monitors are made in single or dual standard versions for displaying television signals encoded in different parts of the world. Rapid retrace time enables the broadcaster to display the entire field of picture information. Observation of both vertical and horizontal blanking insures the broadcaster that he is seeing the whole picture. By delaying the start of the display vertically and horizontally, the vertical and horizontal sync signals are displayed on screen. This display, called "PULSE CROSS", combined with another unique capability of TEKTRONIX picture monitors, A-B or differential input display, makes visual comparison of sync timing errors easy. On the 650 color monitors, reference burst is also displayed in PULSE CROSS. Using the A-B input mode, burst phase errors appear as a color band. When the burst time, width and phase of each signal is equal, they subtract leaving a null on the kinescope display.

After the programs are assembled from the various sound and picture sources, they are sent from the studio to the transmitter or a network of many stations. It is easy to check a video system while off the air as test signals filling the full picture field may be used. This is not possible while on the air, however, because the actual picture fills the field. The first 20 lines of the television picture do not include picture information. This interval, the vertical blanking and sync interval, affords the broadcaster some time for in-service testing. Insert test signals, Vertical Interval Test Signals (VITS), described in detail elsewhere in this issue, are placed on individual lines at the end of the vertical blanking interval. They are out of the active picture area and hence do not interfere with viewing. They undergo the same changes as the rest of the picture signal, however, and provide a fine source of measurement information. TEKTRONIX test signal generators are available to provide both full field and insertion test signals. They are easily programmed so that the broadcaster may insert signals in any available line of either field of the vertical interval. For some applications specific signals have been assigned to specific locations by legislation or by industry agreement.

As you now see, television is not all cartoons and comedy. In addition to the drama on the screen, there is an electronics drama taking place at hundreds of locations between the originating studio and your home. TEKTRONIX television products are at each of these points, from generators for sync and test signals, waveform and vector oscilloscopes for signal analysis, to picture monitors for final evaluation. Around the world one common thread in the television measurement field is the TEKTRONIX television product.



***Stephen D. Kerman** — Steve has a broad background in television broadcasting, having worked closely with the TV broadcasters and networks during his nine years as a field engineer in the New York area. He authored a book entitled ''Color Television and How It Works'', written for the high school level student. Steve received his B.E.E. from Rensselaer Polytechnic Institute in 1960 and is a member of the Royal Television Society and the Society of Motion Picture Television Engineers. His leisure time is shared with his wife and three children, playing the tuba with the Beaverton Community Band and producing motion pictures.*



Measuring Distortions in the Television Signal

by Charles W. Rhodes
Manager, TV Products Development

The television picture signal presents a constant challenge to the state-of-the-art in transmission and measurement capability. As the state-of-the-art improves, the objectives in transmission distance increase; witness the "live-in-color from the moon" pictures sent via satellites, microwave radio relay and coaxial cables to a large portion of the world populace. However, as the novelty of color wore off, increased expectations for more consistent, pleasing and plausible color were felt.

Only a few years ago, distortions were large enough that they could easily be measured, usually after or before the broadcast day began. Today, nearly all measurements are on an "in-service" basis using the vertical interval test signals (VITS). These accompany the program video because, in some cases, the broadcast day is 24 hours long. In other cases, test time over a satellite is just too expensive to justify. The distortions have decreased in recent years adding to the difficulty in measuring them because of noise masking. This is especially true when measured, as is now nearly universal, by means of VITS.

Some of the television test signals are highly sophisticated, but the concepts underlying them and their measurement techniques are hardly confined to television.

Tektronix plays a leading role in the television measurements field. We thought many readers of TEKSCOPE, both in and out of television, might find this measurement technology of interest. Three major aspects of the picture signal establish the basic measurements requirements:

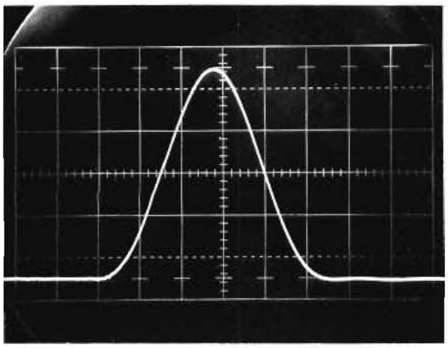


Fig. 1 The sine-squared pulse widely used in testing TV and other bandlimited systems.

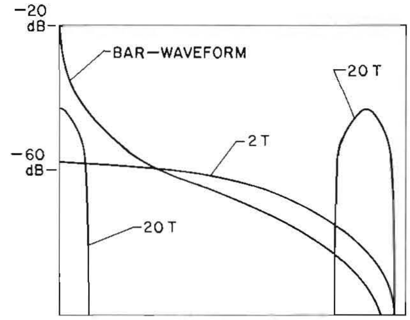


Fig. 2 Energy distribution of sine-squared 2T, 20T and bar signals.

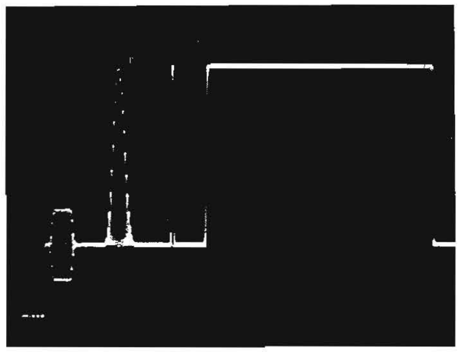


Fig. 3 Sine-squared pulse and bar with modulated 20T pulse.

1) Being an analog signal, serious picture impairments result from small non-linearities in any one of several transfer characteristics. Both PAL and SECAM color systems were developed to reduce picture impairment due to these non-linearities.

2) The signal is band limited due to the scarcity of RF spectrum vs demand. Each TV channel is 6-9 MHz wide. TV is the greatest consumer of the spectrum below 1 GHz and uses significant spectrum above 1 GHz.

3) The mean level of signal is not constant, i.e. average brightness of the TV scene represents a DC video signal level. This must be transmitted with accuracy.

While the highest video frequency is limited by both spectrum conservation and noise, the TV signal is not considered in the frequency domain for measurement purposes. Video waveforms are nearly always non-sinusoidal. Hence, time domain measurements permit measurements which can be correlated with picture impairments such as smear or streaking. For example, tilt in a 10 ms squarewave produces objectionable streaking from left to right; in a 10 ms squarewave, it produces a variation in picture shading from top to bottom.

The time domain may be conveniently broken up into four parts, each giving rise to differently perceived picture impairments:

1) Short Time Distortions (0.125 µs to 1 µs). These affect picture crispness or resolution, horizontally. Undershoots make the picture "soft" or blurry. Overshoots, if not too great in amplitude, tend to enhance picture sharpness. Ringing results in echoes or halos.

2) Line Time Distortions (1-50 µs). These cause horizontal streaking which is positive if due to overshoot or negative if due to undershoot.

3) Field Time Distortion (50 µs-16 ms). These cause shading in the vertical direction.

4) Long Time Distortions (> 16 ms)—cause flicker.

In television, the limit on bandwidth (4.2MHz in North and South America, Japan) makes the usual fast rise squarewave type of test signal of very limited usefulness. Such pulses, introduced into sharp cutoff systems, suffer out-of-band component attenuation which results in ringing in the output pulse at the approximate cutoff frequency (f_c) of 4.2 MHz. This behavior is predicted by theory; there is no need to obscure inband distortions with the out-of-band distortion.

The sine-squared pulse (Fig. 1) is widely used in TV measurements and in other band limited systems. It possesses negligible energy at frequencies above $f = \frac{1}{\text{h.a.d.}}$, where h.a.d. = half amplitude duration, or pulse width, as measured at the 50% points. It is important to note how its energy is distributed within its passband. This is shown in Fig. 2. At $f = \frac{1}{2\,\text{h.a.d.}}$, energy is at −60 dB, thus energy is rather evenly distributed across the passband.

In testing, where the response is not limited by a sharp cutoff at f_c, we use a pulse whose h.a.d. = 0.125 µs. Where the system does have a sharp cutoff characteristic (e.g. the broadcast transmitter, video tape recorder or CATV modulator or demodulator) we use a pulse of 0.25 µs h.a.d. These pulses are 1T and 2T pulses respectively. T, the Nyquist interval, is taken at 0.125 µs in the Western Hemisphere and Japan (where f_c = 4.2 MHz).*

The sine-squared pulse may be compared to impulse testing in time-domain reflectometry. The step type test signal corresponds with the "sine-squared bar" which is actually an integrated sine-squared pulse (See Fig. 3). Mathematically, the risetime, 10-90% amplitude, of an integrated sine-squared pulse = 0.96 of its h.a.d. Its energy spectrum is shown in Fig. 2. In actual practice, this test signal is usually generated by driving a very fast step signal of the desired width and repetition rate into a sine-squared shaping filter. Such filters were originally developed by Mr. W.E. Thompson in England about 1951 (See Fig. 4a).

Recently, Mr. Arend Kastelein of the Television Engineering Staff, Tektronix, Inc., designed very similar filters, but having somewhat improved properties.[1] These are used in nearly all TEKTRONIX sine-squared pulse formation circuits. Fig. 4 b compares the ideal sine-squared pulse with that of Kastelein's 9-pole filter.

It is possible to use the sine-squared pulse or bar to measure Short Time Distortion, one being the integral of the other. The bar is used to measure Line Time Distortion. To facilitate these measurements when using a television waveform monitor, special graticules are often used. Fig. 5 shows one such recently developed graticule[2], which will be available for the TEKTRONIX 529 Waveform Monitors. It is intended to measure the waveform distortion in terms of a picture impairment K factor. In such testing, the worst distortion of the bar establishes the picture

**On the European scene, T = 0.100 us to correspond with a nominal fc = 5 MHz (although some countries actually have somewhat higher bandpass limits).*

TEKTRONIX®

NOVEMBER 1971

NEW PRODUCTS

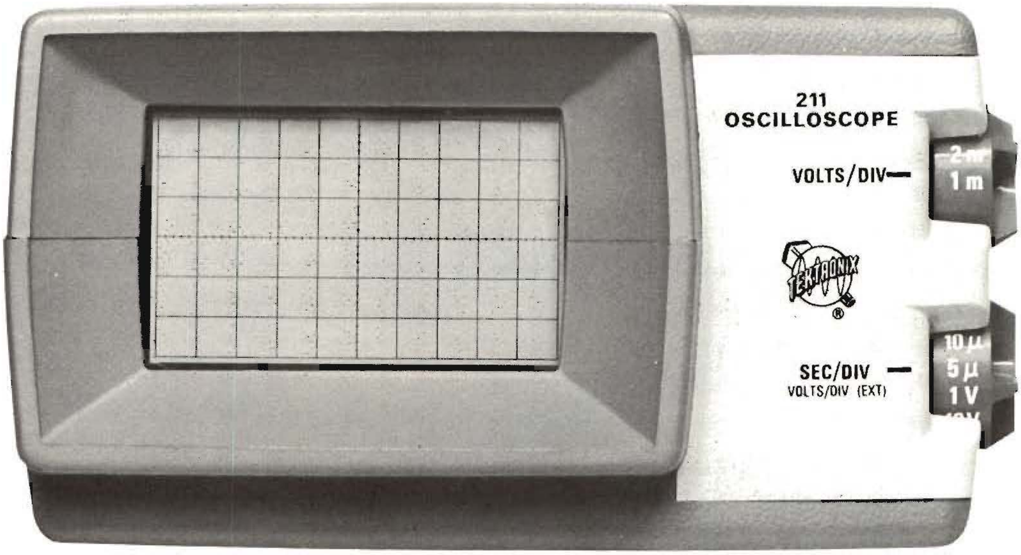
SUPPLEMENT NO. 3 to the MARCH '71 CATALOG

PORTABLE OSCILLOSCOPES

The 211 Oscilloscope weighs only 3 pounds, measures only 3 x 5¼ x 9 inches. Yet it is a complete measurement tool for field maintenance and other applications where space and portability are primary considerations. It's the first laboratory-quality miniscope offering performance, plus unmatched portability and carrying convenience, at a lower price than many other 500-kHz scopes.

In many industrial applications, it's frequently necessary to "float" an oscilloscope. The 211 may be elevated to 700 V (DC + peak AC) above ground when operated from batteries, and 250 V RMS when operated from AC.

The 211 is designed to withstand the shock, vibration and other extremes of environment associated with portability.



Actual Size

Ease of use is evident in the 211. Deflection factors from 1 millivolt to 50 volts/div, and sweep rates from 5 microseconds to 200 milliseconds/div are read out directly from the front panel, where they are related easily to the CRT display. Triggering requires only one rotary control.

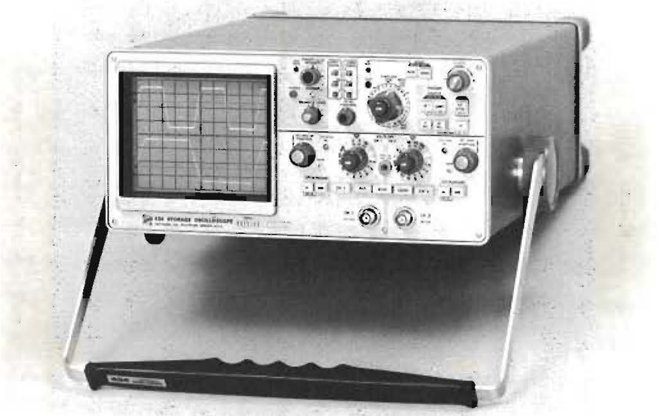
The 211 is equipped with an integral flip stand which tilts the scope to a convenient viewing angle for bench-top operation. The integral probe and power cord wrap around a recessed area in the case. They are out of the way, and you know exactly where they'll be when you reach your next job.

An oscilloscope used in maintenance applications should be ready to travel when needed. This means that it has to be easy to service to eliminate the purchase of back-up scopes. The 211 disassembles quickly and easily into its modular components for easy access to internal components.

The internal DC source contains 10 NiCd cells providing 3.2 to 4.5 hours of operation. A battery meter indicates charge level. An external AC source can be used to operate the 211 and the internal charger. Maximum recharge time is 16 hours.

The 211 covers an extremely wide range of applications including industrial controls, mobile electronic facilities, audio communications, telephone and military applications, office equipment, logic level isolation, numerical control equipment, electronic scales, motor controls, interoffice and interplant communications, avionics, marine electronics, frequency translator maintenance and others.

211 Oscilloscope $545



The 434 Storage Oscilloscope, Option 1, a companion to the 434 Storage Oscilloscope described in the July Supplement, provides an increased single sweep writing speed of 500 cm/ms. Enhanced writing speed is increased to 5000 cm/ms.

Bandwidth is DC to 25 MHz and deflection factors are 1 mV/div to 10 V/div. A wide range, direct-reading magnifier expands the horizontal display up to a maximum of 50 times in six steps. 20 ns/div is the fastest magnified sweep. To save operator time and reduce errors, lighted knob skirts read out scale factors even when using the recommended 10X probe.

434 Storage Oscilloscope, Option 1 .... $2175

U.S. Sales Prices FOB Beaverton, Oregon

For further information or a demonstration of these products, please contact your local TEKTRONIX Field Office or return the enclosed inquiry card.

The PLOT-10 software provides outstanding versatility and is compatible with over 20 timesharing systems, with IBM 360/370 systems and a host of mini-computers. Also, PLOT-10 provides the most extensive capabilities in graphing and application-interface routines. The new PLOT-10 software package lets computers display more information in less time than ever before.

The 4610 Hard Copy Unit provides permanent copies of the alphanumerics and graphics displayed on the 4010 Computer Display Terminal. Copy medium is 3M Type 777 Dry-Silver paper and copy size is 8½ x 11 inches. The easy-to-handle copies are convenient for communication, documentation, recording and filing uses.

4610 Hard Copy Unit $3550

U.S. Sales Price FOB Beaverton, Oregon

THE FOLLOWING PRODUCTS WERE INCLUDED IN PREVIOUS NEW PRODUCT SUPPLEMENTS

Supplement No. 1

7904 500-MHz Oscilloscope System
432 25-MHz Portable Oscilloscope
434 25-MHz Portable Storage Oscilloscope
453A-1,-2,-3,-4 60-MHz Portable Oscilloscopes
1401A/1401A-1 Portable Spectrum Analyzers
147 NTSC Test Signal Generator
148 EBU Insertion Test Signal Generator
630 Monochrome Picture Monitor
650 Color Picture Monitor
2620 Stimulus Isolator

26A2 Differential Amplifier
C-5 Camera
C-59 Camera
Writing Speed Enhancer
P6060/P6061 Probes
Calculators
1711 Machine Control Unit
1791 NC Program Verifier
4002A Graphic Computer Terminal

Supplement No. 2

7L12 Spectrum Analyzer
7CT1N Curve Tracer
5103N/D15 Storage Oscilloscope
R5103N/D15 Storage Oscilloscope
5A13N Differential Comparator
5A14N Four-Trace Amplifier
5A22N Differential Amplifier
5CT1N Curve Tracer

172 Programmable Test Fixture
1501 Time Domain Reflectometer
P6056 Probe
P6057 Probe
603 Storage Monitor
604 Display Monitor
4602 Video Hard Copy Unit
S-3160 LSI/MOS Test System

For further information or a demonstration of these products, please contact your local TEKTRONIX Field Office or return the enclosed inquiry card.

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661, 5T3, 4S1. $1000. Mr. D. Kahler, Fincor, Inc. 1000 E. Boundary Av., York, Pa. 17403 (717) 843-7841

453, 2-P6010, 2-P6028 Probes. Make offer. Barry Noll, Famco Machine Co., 3100 Sheridan Rd. Kenosha, Wi. 53140 (414) 654-3516

517A. Best Offer. Robt. A. Miller, Renton School Dist, 410 Wells Av. S. Renton, Wa. 98055 (206) 235-2437

561B/3A6/3B3/P6006. $1500. Herman Bourgeois, 15432 Hobart Rd., Issaquah, Wa. 98027 (206) 392-5487

D-54 $475. Eric Breece, 30 Otis Way, Los Altos, Ca. 94022 (415) 941-2376

545B, 1A1, 1A6, 202-2. $1800. Larry Glassman, 5584 Benton Woods Dr. NE, Atlanta, Ga. 30342 (404) 255-5432

453 $1600. Henry Beyreis, HMB Enterprises, 4733 Brooks, Montclair, Ca. (714) 626-8015

TLD43 w/2-A plug-ins. $400. Mr. Vitale, Vitale's Electronics, RD 6, Box 377, Newton, NJ 07860 (201) 383-5565

524AD, 202-2 scope cart w/probe. Best offer. Dennis Dunbar, WSKG-TV, Box 954, Binghamton, NY 13902 (607) 798-7177

545A, CA, L, 132. $1300. Frank Cameron, 490 Cherry Av, Los Altos, Ca. 94022 (415) 941-2842

D Plug-in $100. James McCoy, Echometer Co., 1640 P.B. Lane, Wichita Falls, Tx. 76302. (817) 767-0218

454. Dan Stalling, Electra/Midland Corp. PO Box 760, Mineral Wells, Tx. 76067 (817) 325-7871

516A w/cover & viewer $700. Wm. Kraengel, 65 Sunset Rd., Valley Stream, NY 11580 (516) 825-6436

RM144, $1600. Bill Canora, WHNB-TV, 1422 New Britain Av., West Hartford, Ct. 06110 (203) 521-3030

524D w/Scopemobile $300. T. Arthur Bone, Poole Broadcasting Co. WPRI-TV, 24 Mason St., Providence, RI 02903 (401) 521-4000

543A, L, D, $850. Leo Wulff, PO Box 172, Cockeysville, Md. 21030

INSTRUMENTS WANTED

576. Jim Derda, 12741 Las Nietas Rd, Santa Fe Springs, Ca. (213) 698-3712

531A. Brian Y. McCay, 10288 Anderson Rd., Granger, In. 46530 (219) 674-5096

549/1A1. United Car Canada Ltd., Box 500, Stoney Creek, Ont., Canada. (416) 664-4401

507. Wm. A. Irby, ITE Imperial, 1900 Hamilton St., Philadelphia, Pa. (215) 822-1306

1A1. Ray Sollars, 4101 N. Figueroa St., Los Angeles, Ca. 90065 (213) 225-1564

TQ Scope. J.C. Cunningham, Cox Cable Communications, Inc. 1601 W. Peachtree St., Atlanta, Ga. 30309

535A w/ or wo plug-ins. Electronic Institutes, 1402 Penn Av., Pittsburgh, Pa. 15222 (412) 471-3962

535. M. Rice, Box 1460, St. Charles, Mo. 63301

TEKSCOPE Classified Ads Supplement

November 1971

INSTRUMENTS FOR SALE

561A, 3A1, 3B3, 2-P6006 Probes, $1100 package price. Richard Hertel, ITT Electron Tube Div, 3700 E. Pontiac St., Ft. Wayne, Ind. 46803 (219) 743-7571 X703

2-3T77 Plug-ins. $300 ea. John R. Sewell, RCA Corp, 3900 RCA Blvd. M/S 30-7, Palm Beach Gardens, Fl. 33403

565 w/3A3 Amp & 3C66 Amp; 205-3 scope cart. Peter Schiff, SMEC, Box 117, Schwenksville, Pa. 19473 (215) 287-8611

561A, 3A1, 63 Diff. Amp, 3B3, 2B67, Roger Kloepfer, 1428 Ormond St., Lansing, Mi. 48906 (517) 487-6111 X392

561A (2), 555, 3A74, 3A1, 2B67 (2), 503, C27P, CA (2), 21A, 22A. F. Modrarrad, Teledyne Ind., Inc. 703 37th Ave., Oakland, Ca. 94601 (415) 532-7404

585, 547, 544 (4), 543, 541, 533 (2), 531A (13), 53C (2), 53/54A (2), B (17), CA (2), L (13), M, 82, 1A1 (3). E. Pulaski, Ferroxcube Corp., Mt. Marion Rd., Saugerties, NY 12477

531A w/CA $800. J. Steskal (414) 224-7533

D54. D B Electronics, 76 Dennisville Rd., Cape May Ct. House, NJ 08210 (609) 465-5005

515A, 543, 545A, 547, CA, 1A4, 1A2, 2022, Ind. or as system. E.J. Oislander, 140 Sandford Blvd, East, Mt. Vernon, NY. 10550 (914) 664-7530

561A, 3A1, 3A72, 2B67. Max Scholfield, Crown Intl., PO Box 1000, Elkhart, Ind. 46514 (219) 523-4919

533A w/1A1. Make offer. G. Byrd, Mostek Corp, 1400 Upfield, Carrollton, Tx. 75006 (214) 242-1494

454 $2500 Gerald Durbin, Westminster, Ca., (714) 531-6008

316, $475. RM15, $525. Exc. cond.Cartronics, PO Box 3177, Indialatic, Fl. 32903 (305) 723-1821

TLS54. C. Patnoi, Unirad, Inc. 4665 Joliet St., Denver, Co. 80239 (303) 364-7258

531, 53B, $300. Eugene Mirro, PO Box 274, Highstown, NJ 08520 (609) 799-1495

180A, $150; P6019, $75; 81, $25; W, $225; 202-1, $45; 514, $225; 512, $200. Goslin Electronics, 2921 W. Olive, Burbank, Ca. 91505 (213) 848-0776

454, 200-1 Scopemobile, both for $1700, Franz Zenker, Box 72, Lake Peekskill, NY, 10537 (914) 528-8194

1L5, $600. Sell or trade. J.R. Stewart, Santa Rita Technology, 960 N. San Antonio Rd, Los Altos, Ca. 94022

CA Plug-in, new, $250. Barry Synder, Xerox Data Systems, 701 S. Aviation Blvd., El Segundo, Ca. 90245 (213) 679-4511

R140, 1½ yrs. old, exc. cond. $1700. Art Phelps, Davis, Ca. (916) 752-2182

453A, C30AP, P6011, like new, make offer. Ray Pitts, 4376 Haines Av, San Jose, Ca. 95123 (415) 966-2691

323, 1 yr. old, $800. Gen. Business Machines, 1108 Commonwealth Av., Boston, Ma. (617) 232-1186

611. Ernest G. Burgess, Computer Animation Ind., Inc., PO Box 832, Tullahoma, Tn. 37388

R564B (4), R561B (2), 2A63 (7), unused, Wm. Schell, % Computest Corp. (609) 424-2400

526. $650. Mr. Fred Hodge, Minnesota Mining & Mfg. Co., Camarillo, Ca. 93010.

422 S/N 13274. McPherson Industries, 20050 Sherwood, Detroit, Mi. 48234 (313) 892-3020.

543B/H/CA/Scopemobile cart/P6015/X10/X1. $1800. 515A/X10/X1, Scopemobile cart, $700. Daniel J. Kubat, Gen. Communications Co., 827 S. 20th St., Omaha, Nb. 68108 (402) 341-8069.

545B, 1A2, M, W. Larry Luce, Pac. SW Airlines, 3110 Goddard Way, San Diego, Ca. 92112 (714) 297-4781

535/CA/E $970. 515A, $630. John K. Green, Box 1038, Boulder, Co. 80302

535A/CA. db Electronic Enterprises, 13526 Pyramid Dr., Dallas, Tx. 75234 (214) 241-2888

531/CA/D. George Bolen, 1012 Hobbs St., Sac City, Ia. 50583 (712) 662-7860

575. Jim Derda, 12741 Las Nietas Rd, Santa Fe Springs, Ca. (213) 698-3712

422 w/2 Probes. AC only. $800. E.J. Hokanson, 6517 N. Atwahl Dr., Glendale, Wi. 53209 (414) 352-2336

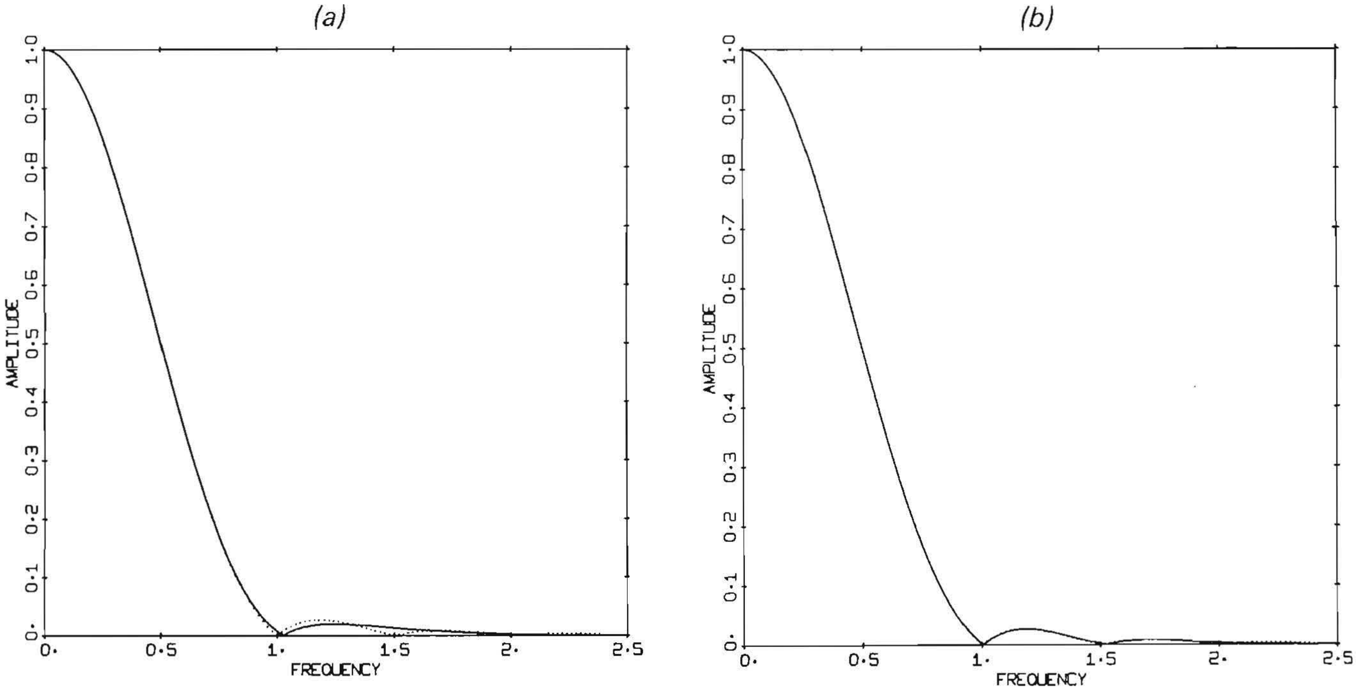


Fig. 4 Spectral distribution of approximated sine-squared pulses from Thompson's 7-pole network (a), and Kastelein's 9-pole network (b). The dotted line represents the spectral distribution of an exact sine-squared pulse.

impairment so measurement is reduced to a quality-oriented number. The derivation and exact manner of use are covered in Ref. 2.

In vertical interval testing, the test signal has a repetition rate of 30 Hz and it is gated into the video system on a chosen line in between fields during the vertical blanking interval. It is possible to conduct Short Time Distortion and Line Time Distortion tests in this way. It is not possible to test for Field Time Distortion, except in measuring the tilt of the vertical blanking pulse itself, a test not wholly adequate. Nevertheless, it is all one can do or needs to do on an in-service basis.

On an out-of-service basis, the most sensitive test signal for Field Time Distortion is a 60 Hz squarewave. This simple technique is not possible in testing TV transmitters and certain other equipment, e.g. stabilizing or clamping amplifiers which require sync pulses to be present for their proper operation.

Tektronix has developed a "field rate squarewave" with composite sync pulses added. This is in the new 147 and 148 test generators and is shown in Fig. 6. This is not a true squarewave because of the sync and blanking pulses. It will exhibit the same sensitivity to distortion as a true squarewave of 60 Hz (50 Hz in the 148, designed for 625/50 standards). Fig. 7 shows a tilt due to a 0.1 second RC coupling time constant.

The usual test signal used for both Field Time Distortion and Line Time Distortion is the "window". This consists of a sine-squared bar approximately 25 µs in duration which appears on about half the TV lines per field; hence, its appearance in Fig. 8 which exhibits less tilt for the same 0.1 second RC coupling time constant.

The new "field squarewave" signal is nearly twice as sensitive as the conventional window to Field Time Distortions. The TEKTRONIX 147 (and 148) generate both the field squarewave and window signal. Sensitivity of the window signal to Field Time Distortion is shown in Fig. 8. The window signal is unmatched in detecting Line Time Distortion in picture monitors or in using picture monitors. Frequently, in using the window, its sensitivity to Field Time Distortion hinders measurement of Line Time Distortion. The trace thickening in Fig. 9 is the result of Field Time Distortion, and in this case it is more difficult to assess Line Time Distortion.

The TEKTRONIX 147 (and 148) also provides a sine-squared pulse and bar signal. This is identical to the window, except that the bar component is present on every active picture line. This substantially reduces the 60 Hz

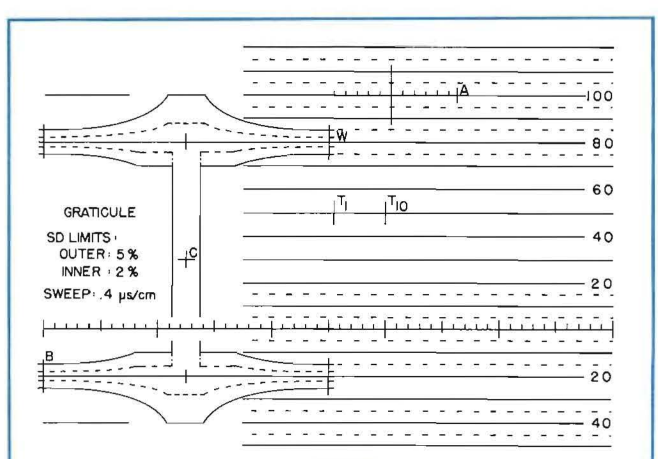


Fig. 5 The new TEKTRONIX graticule for K-factor evaluation of sine-squared pulse and bar testing.

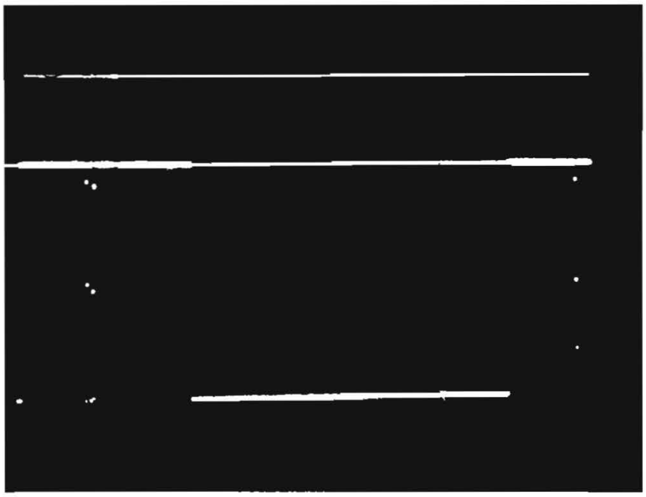


Fig. 6 Field rate squarewave available from the 147 and 148 test signal generators.

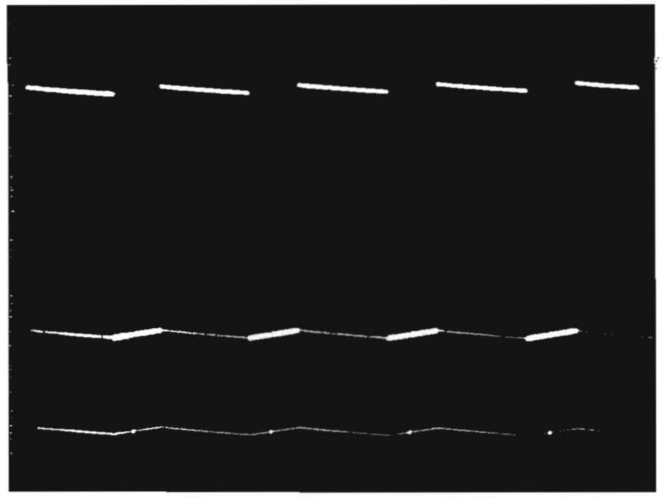


Fig. 7 Tilt in field rate squarewave due to 0.1 sec RC coupling time constant causes Field Time Distortion.

components present; hence, this signal is rather unaffected by Field Time Distortion (Fig. 10).*

Of the three test signals, the window is the best known, and is good for Field Time Distortion, Line Time Distortion and Short Time Distortion; but, it is fundamentally a full field signal. Better results in measuring Field Time Distortion may be had with the new field squarewave, or, to eliminate the effects of Field Time Distortion in measuring Line Time Distortion, the sine-squared pulse and bar signal is effective. Both the window and the sine-squared pulse and bar signals may be set up for 2T or T pulse and bar transitions as desired.

The sine-squared pulse and bar signal is available as a VIT signal and/or full field. Both pulse and bar and window signals include a modulated sine-squared pulse (12.5T). This pulse measures two transmission parameters of importance to color quality, relative chrominance-to-luminance gain and relative chrominance-to-luminance delay. Relative chrominance/luminance gain distortion causes errors in saturation. These errors are especially significant when viewing several stations, or even successive programs on one station. Of course, the home receiver can be readjusted, but with relative chrominance-to-luminance gain distortion kept low, the public does not have to correct it manually.

This photo was taken using the 0.1 sec RC coupling, same as Fig. 7 and 8.

Relative chrominance/luminance delay is another matter. There is no customer control for this transmission distortion. The public is stuck with the color misregistry. This is not like misconvergence which is objectionable principally on black and white pictures. Relative chrominance/-luminance delay affects only the color programs. It is most easily detected with red lettering against a white background, the red blurring and displaced, generally to the right. This distortion is caused by group envelope delay distortion. It can occur at almost any part of the TV system, but it is especially important in TV transmitters, receivers themselves and in CATV systems.

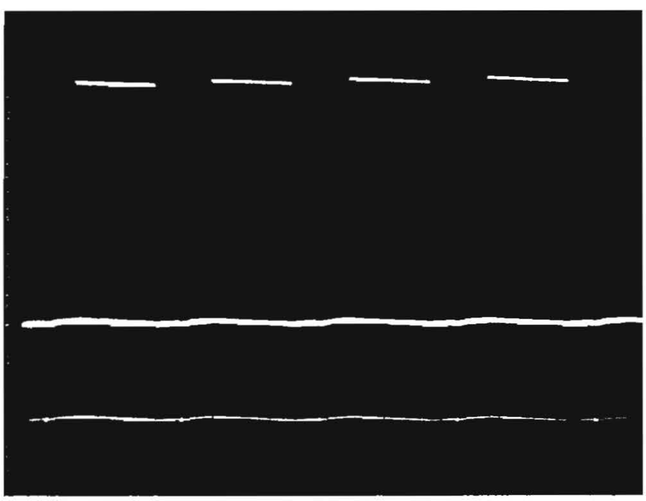


Fig. 8 The "window" test signal yields less sensitivity to Field Time Distortions as evidenced by less tilt due to the 0.1 sec time constant.

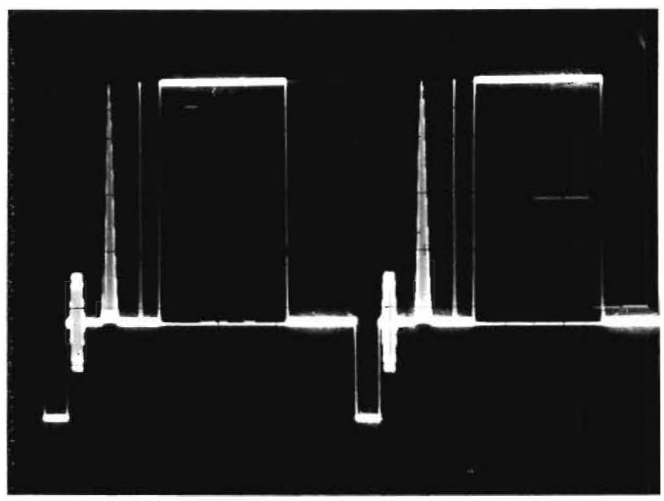


Fig. 9 Trace thickening due to Field Time Distortions makes it more difficult to assure Line Time Distortions.

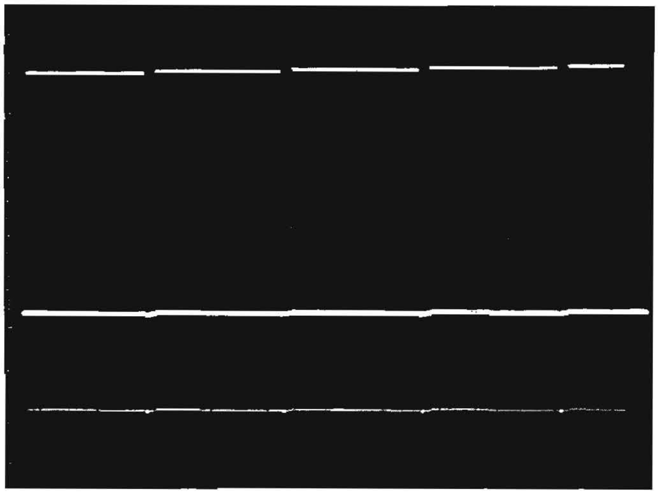


Fig. 10 The 147 and 148 sine-squared pulse and bar signal is present on every line thereby reducing 60 Hz components present.

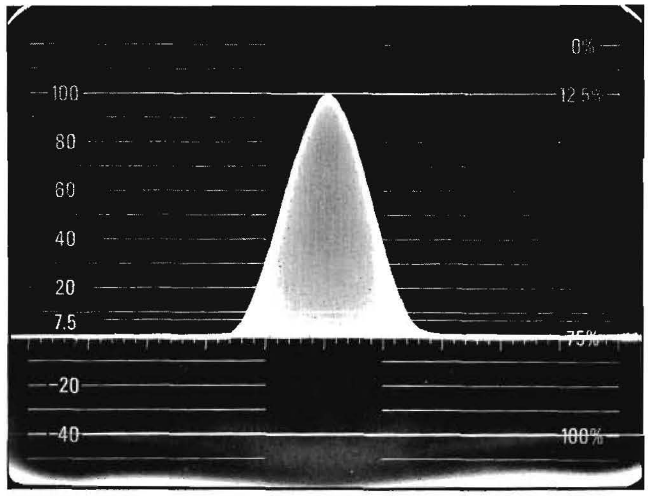


Fig. 11 The new 12.5T modulated sine-squared pulse developed by Tektronix to test for relative chrominance / luminance gain and delay distortions.

These distortions generally appear together. They may be measured using the new 12.5T modulated sine-squared pulse developed by engineers at Tektronix as a proper scaling of the 20T signal originated in Germany.

The 12.5T modulated sine-squared pulse will be standard (on Line 17) on NTSC transmissions via satellite to and from North America. It is expected to be used by the networks in North America on Line 18 or 19 as a component of national test signals. It is also required to be radiated by VHF transmitters operating under remote control, and by UHF transmitters operating under remote control after April 1, 1972 (by recent FCC rule making)[3].

The measurements we've been discussing are but a few of the many needed to insure faithful reproduction and transmission of the video program from the scene of action to your home television receiver. New techniques and products being developed at Tektronix will enhance, still further, the broadcasters' ability to bring you sharp, bright color pictures from any point on the earth, and beyond.

REFERENCES

Ref. 1 Arend Kastelein, "A New Sine-Squared Pulse and Bar Shaping Network," IEEE Transactions on Broadcasting, Vol. BC-16, Number 4, pp. 84-89, December, 1970.

Ref. 2 Hans Schmid, "The Measurement of Short-Time Waveform Distortion in NTSC TV Facilities," IEEE Transactions on Broadcasting, Vol. BC-17, Number 3, pp 83-87, September, 1971.

Ref. 3 Federal Communications Commission, FCC 71-879 66374, Docket 18425, Amendment of Part 73, Subpart E of the Commission's Rules and Regulations Governing TV Broadcast Stations.

__Charles W. Rhodes__—Charlie attended the University of California at Berkeley and worked with the Columbia Broadcasting System for two years before coming with Tektronix in 1956. His projects have been largely centered around his continuing interest in the field of television. He has designed or directed the design of all of the vectorscopes, television waveform monitors and picture monitors introduced by the company since 1957.

He holds several U.S. and foreign patents relating to television and has published several technical papers.

His professional affiliations include Senior Member IEEE, member of SMPTE and of the Royal Television Society. He is a member of the IEEE subcommittee 2.1.4 (Video Techniques), a subcommittee chairman of TR 4.4 of the Electronic Industries Association, a subcommittee chairman of the J.C.I.C. and has recently been asked to join the U.S. Study Group 10/11A (Audio/Video) for the CCIR (International Radio Consultative Committee) of the ITU (International Telecommunications Union).

TEKNIQUE: *USING THE 144 AS A SIMPLE SPECIAL EFFECTS GENERATOR*

by Stu Rasmussen, Motion Picture and TV Producer

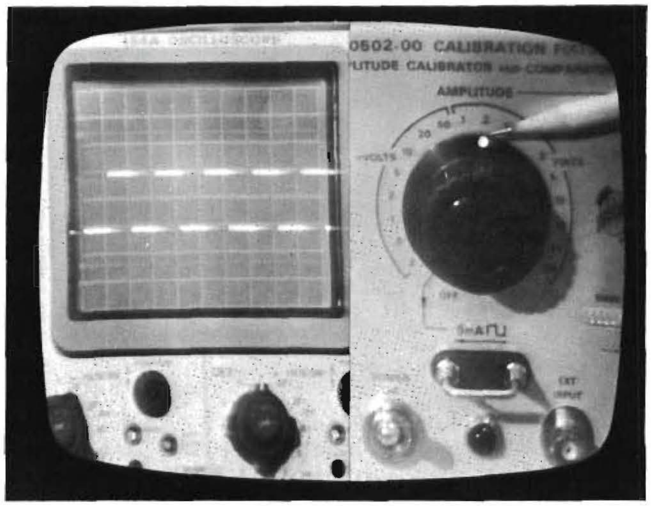
Maximum usefulness of each piece of equipment in a television production unit is a practical goal for any production staff. One instrument which can be used for a variety of purposes is the TEKTRONIX 144 NTSC Test Signal Generator. In addition to providing highly accurate monochrome and color test signals, the 144 can serve as the master sync and drive pulse generator for the entire station. It can also be used as a simple special effects generator to provide a wipe between two video sources.

The composite video output from the 144 is either of two types of test patterns, the components of which are determined by the programming of the generator. A front panel switch, the COMP VIDEO PATTERN, determines which of the two signals will be supplied to the output. In the SINGLE PATTERN position, the output is determined by the positions of the switches on the front panel. Color bars, modulated staircase or modulated pedestal can be selected. In the MULT PATTERN position, the output is internally programmed to provide convergence, color bars, gray scale, and two external video inputs. There is also a provision to wipe horizontally between the two external video inputs during the time they are displayed on the screen. Programming of this test signal is accomplished inside the instrument by movable jumpers which allow the user to change the pattern to suit his needs. With proper programming, the 144 can be used as a combination test signal generator and special effects generator.

The first step in changing the programming of the instrument to use it as an effects generator is to change the multiple pattern display to give a full field signal of the external video inputs. To do this, place the COMP VIDEO PATTERN switch in the MULT position. Locate the Field Timing circuit board situated on the upper side of the 144, directly behind the front panel SYNCHRONIZATION switches. On this board are five rows of colored jumpers, the functions of which are explained in the 144 manual. Rows B and A are, respectively, the external-video start and stop controls. These jumpers digitally select the line of the video signal at which the instrument will switch to and from the external video.

To set the unit for full field external video, a start line of 22 and a stop of 0 are required. To set the start line, remember that the actual line count is the binary count selected by the jumpers, plus 6. To set the start line to 22, it is necessary to set the jumpers in row B to a binary count of 16. The stop line is set to 0 (zero) so that the unit will reset during the vertical interval instead of during an active portion of the field. A continuous field display of the two external video signals is now programmed.

If video from two sources is applied to the rear panel A & B VIDEO INPUTS, a full field display of the video from these sources will appear at the VIDEO OUTPUT connector, and the position of the horizontal transition or wipe can be varied by the front panel EXT VIDEO WIPE control.



A horizontal wipe permits display of both the oscilloscope trace and the signal source.

If the 144 is mounted at some distance from the studio control room, as is often the case, some means of remote control of the generator function and wipe position would be desirable. The wipe position can be remoted by taking a +3.6 volt source and a ground from the 144 as shown in Fig. 1 and connecting them to a 2KΩ pot. The wiper is returned to the 144 and replaces the connection to the wiper of the EXT VIDEO WIPE control mounted in the 144. It will probably be necessary to add a fairly large capacitor between ground and the lead to the wiper of the remote wipe control. This will eliminate stray pickup which could cause the split transition to be noisy. A typical value would be 47 μF at 10 volts.

We now have control of the wipe position of the 144, but in order to switch it from the special effects mode to the test signal it is necessary to operate the front panel switch on the 144. (Changing the PATTERN switch to the SINGLE position will provide the 144 test signal programmed by the front panel switches.) It would be far more convenient to do this in the control room, and if it could be done automatically, that would be so much the better.

The video output of the 144 is most likely to go to the production switcher. Color bars should be available as one "camera" input and the special effects output as another input on the program row. All that is required to get automatic switching of the function of the 144 is to add a relay within the 144 to be operated by the tally light

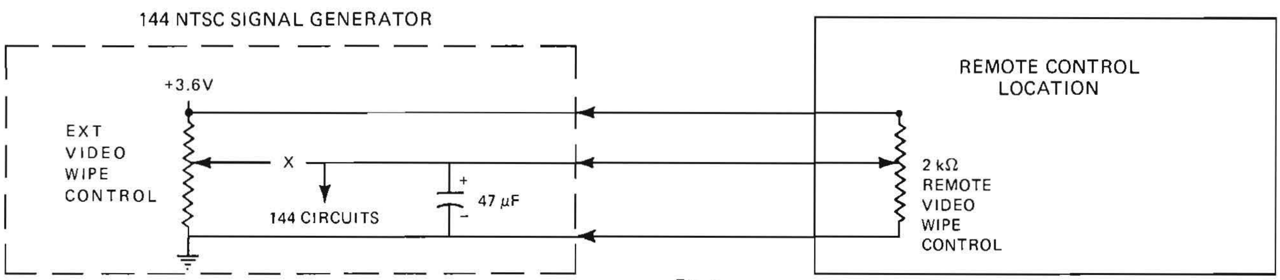


Fig. 1

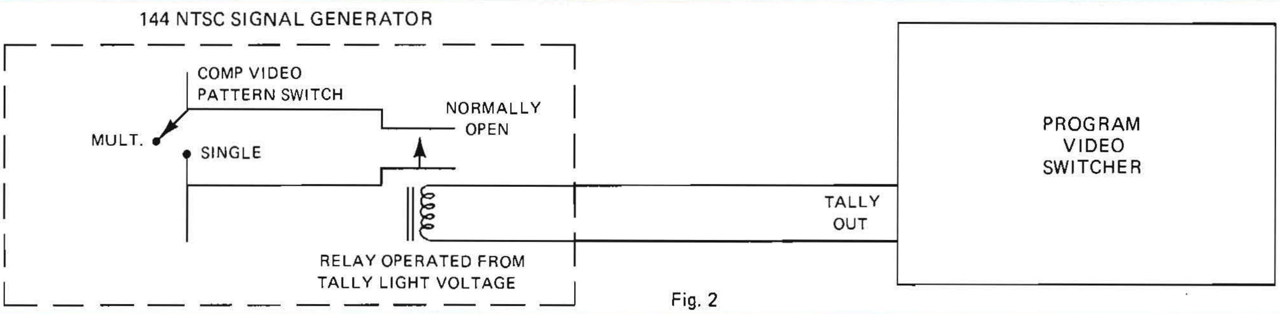


Fig. 2

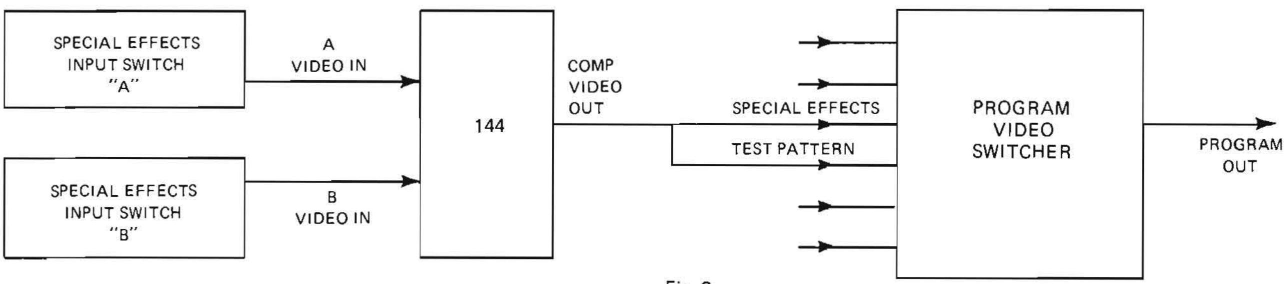
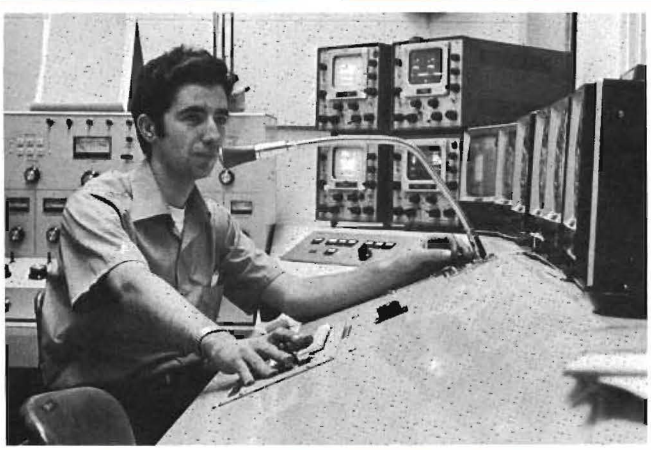


Fig. 3

voltage from the color bar input column. If the test pattern signal is desired, the relay closes the contacts of the PATTERN switch in the 144, and if it is desired to use it as an effects generator, the relay opens the circuit. See Fig. 2. Note that the PATTERN switch on the 144 must be in the MULT position for the relay to have any effect.

Since the composite video output appears at a single BNC connector on the rear panel of the 144, provision must be made at the video switcher to couple this single output to both the special effects and test pattern inputs of the switcher as in Fig. 3.

As an added benefit, the 144 can be programmed by front panel controls to insert VITS in the video output for on-the-air testing of video circuit functions and adjustments.



***Stewart A. Rasmussen** — Stu started his career with Tektronix three years ago calibrating and troubleshooting production line instruments. From the test department, he moved to the communications department, and then to the education and training group. Here, a long-standing interest in TV and movie production blossomed into a new career for Stu when an opportunity came to work with the group producing video tapes and movies used for training at Tektronix.*

Stu is currently pursuing studies in this field at Portland State University. He is also a member of the Society of Motion Picture Television Engineers.

SERVICE SCOPE

A QUICK-CAL PROCEDURE FOR THE 520 VECTORSCOPE

by Ed Handris, Factory Service Technician

A well-known quote says, "A workman is no better than his tools." Applying this to television broadcasting we might say, "Your color TV picture is no better than the equipment used to produce it."

The TEKTRONIX 520 Vectorscope plays a key role in providing the high-quality color TV programs we all enjoy so much. The quick-cal procedure that follows will help to assure that this important "tool" is in good working order.

This procedure is not intended to replace the more thorough calibration performed by TEKTRONIX Service Centers on instruments sent to them for repair and calibration. It does provide a check of the important operating characteristics of the 520 and, once the technician is familiar with the instrument, can be performed in an hour or less. Here is the equipment you will need:

- An oscilloscope with at least 10 MHz bandwidth such as the 453 or 547.
- A 140-Series NTSC Signal Generator.
- An NTSC Calibration Fixture (TEKTRONIX Part No. 067-0546-00)
- A precision voltmeter capable of measurements to better than 1%.
- A DC Voltmeter (VOM) 20,000Ω /volt.
- Three 75Ω cables, two 75Ω terminations, a BNC T connector and some adjustment tools.

Now let's take a look at the procedure:

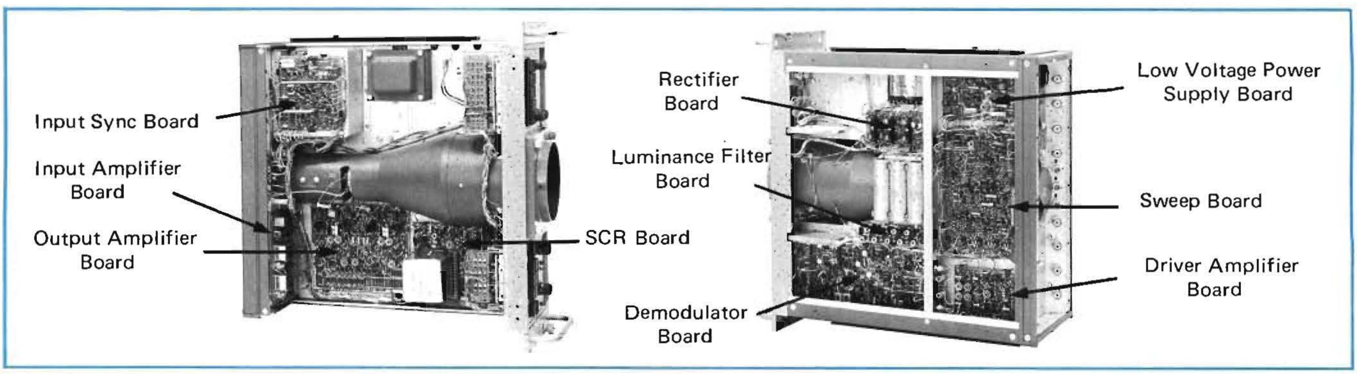
1) Check the crystal oven pre-heater operation:
Before turning on the 520, connect the VOM between test point 295 (TP295) on the Subcarrier Regenerator Board and ground. The voltage should be -15 volts when the 520 is first turned on and then rise to about +20 volts within three minutes. This indicates the crystal oven has come up to temperature.

2) Check the low voltage supplies:
Use the precision DC voltmeter to check the -15 volt supply. This supply is the reference for the other supplies. It should not be adjusted if it's within tolerance as it will cause a shift in the other supplies and possibly a change in the calibration of the 520.
   a) -15 volts, ±0.5%, read on pin Z of the low voltage power supply board. Adjust R1588 if necessary.
   You may use the VOM for checking the following supplies:
   b) +10 volts, ±3.5%, read on pin T of the low-voltage board.
   c) +100 volts, ±3.5%, read on pin H of the low-voltage board.
   d) +275 volts, ±7%, read on pin A of the low-voltage board.
   e) +3.6 volts, ±5%, read on pin X of the Input Sync board.
   f) -3875 volts, ±3%, with Intensity control set to mid-range. Read on pin 2 of the CRT socket. To get to this pin, turn off the power to the 520, remove the metal CRT protector cap on the rear, then remove the cover from the CRT socket. Pin 2 is the red-on-white wire.

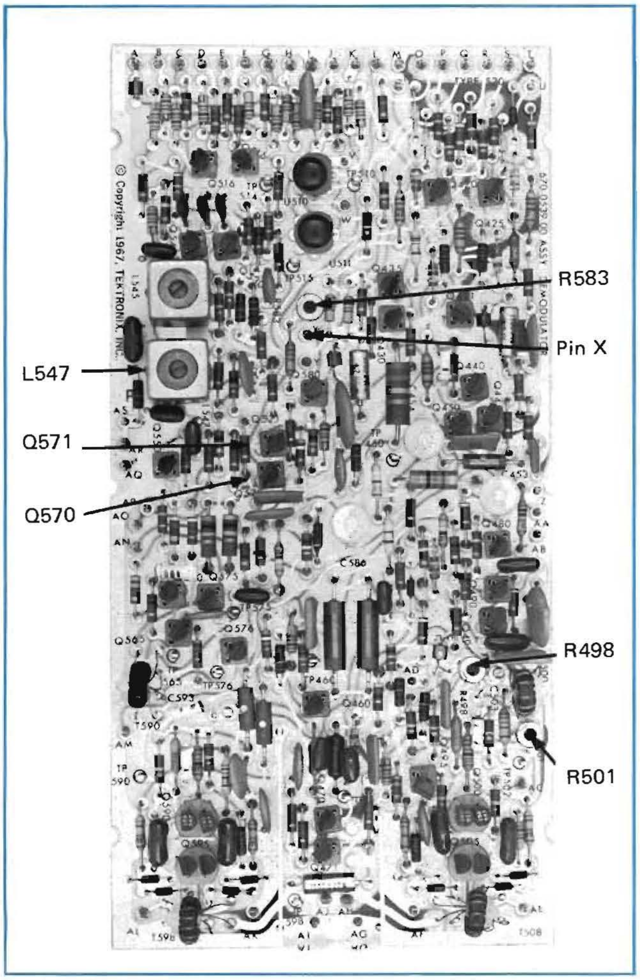
Check to see that the voltage stays within ±20V of the mid-range value when the Intensity control is set at the maximum and minimum positions.

3) Check the Luminance Calibrator:
Depress: Y
FULL FIELD
A CAL
Connect the precision DC voltmeter to pin X on the Demodulator board. Remove Q570 and note the reading (about -0.002 volts). Install Q570 and remove Q571. The voltage reading should be exactly 1 volt more positive than the previous reading or about +0.998 volts. Adjust R583 if necessary. Reinstall Q571.

4) Check the DC Balance of the R-Y, B-Y and Y Amplifiers:
Depress: VECTOR
FULL FIELD
Connect the VOM to the following test points in the Driver board and adjust as indicated:



Location of the circuit boards in the 520 Vectorscope.



Demodulator Board test point and control locations.

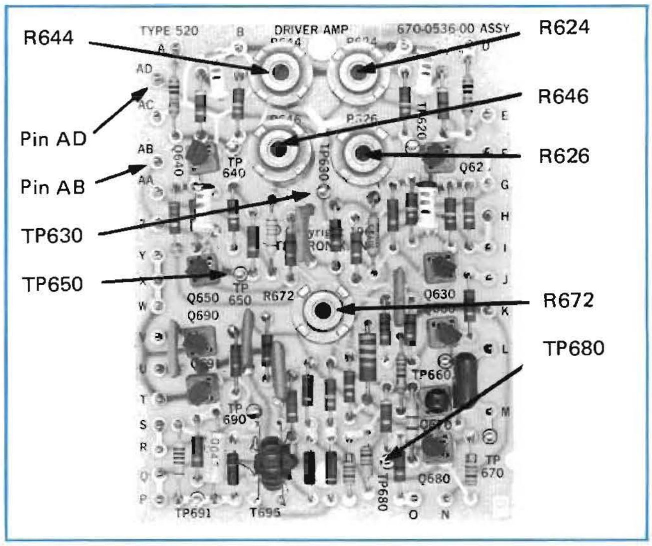
TP 630—Adjust R624 for 0 volts
TP 650—Adjust R644 for 0 volts
TP 680—Adjust R672 for +0.5 volts

5) Check the Unblanking Bias Adjustment:
Depress: VECTOR
FULL FIELD
A CAL
A circle will be displayed. Adjust R1478 on the rear panel of the 520 for uniform intensity of the circle.

6) Check the Common Mode Level Adjustments:
Depress: VECTOR
FULL FIELD
Set the INTENSITY control so the displayed spot doesn't burn the phosphor. Center the spot using the HORIZ and VERT POSITION CLAMP controls on the 520 front panel. Connect the VOM to TP980 on the Output Amplifier board and adjust R985 for +5.6 volts. Check TP870 and adjust R875 for +5.6 volts.

7) Check FOCUS and ASTIGMATISM setting:
The front panel FOCUS and rear panel ASTIGMATISM should be set for a well defined spot.

8) Check the BEAM ROTATE and ORTH adjustments:
Depress: VECTOR
FULL FIELD
A CAL
Remove the lead from pin AB on the Driver board. You should have a vertical line. Adjust BEAM ROTATE on

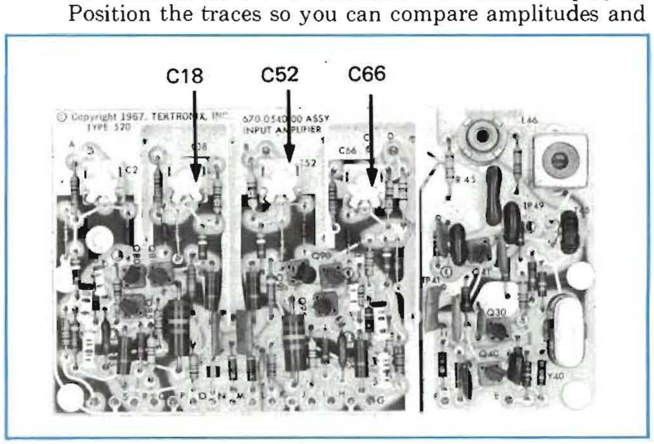


Driver Amplifier Board test point and control locations.

the front panel if necessary. Reconnect lead to pin AB and remove lead on pin AD. You should have a horizontal line. Adjust ORTH control on the rear panel if necessary. Reconnect lead to pin AD. The BEAM ROTATE and ORTH controls interact so recheck as needed

9) Check Burst Flag Timing:
Depress: VECTOR
FULL FIELD
CH A
AΦ
Feed composite video from the 140 NTSC Signal generator into CH A input on the rear of the 520. Terminate CH A and CH B loop-thrus with 75Ω. These terminations should remain in place for the remainder of the cal procedure unless noted otherwise. You should have a vector display. Set the A PHASE control so the burst vector is at the 90° position. Now depress the LINE SWEEP button. Turn down the intensity so you can see the brightened portion of the display and adjust the BURST FLAG TIMING control on the front panel for equal brightness either side of the peak of the waveform.

10) Check the Video Amplifier Gain:
a) Luminance Gain:
Depress: Y
FULL FIELD
A CAL
B CAL
You should have two calibrator waveforms displayed. Position the traces so you can compare amplitudes and



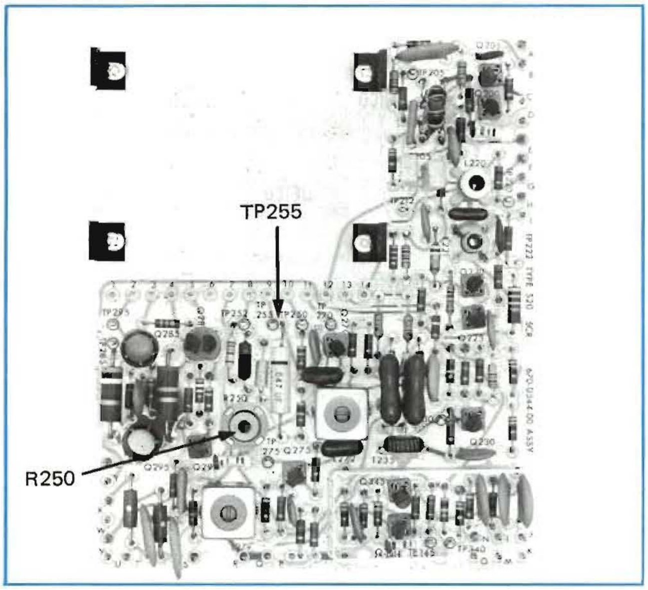
Input Amplifier board control locations.

set the front panel B CAL screwdriver adjustment so the waveforms are the same amplitude. Run the thumbwheel A and B GAIN controls through their range and check for open spots. Return them to the calibrated position.

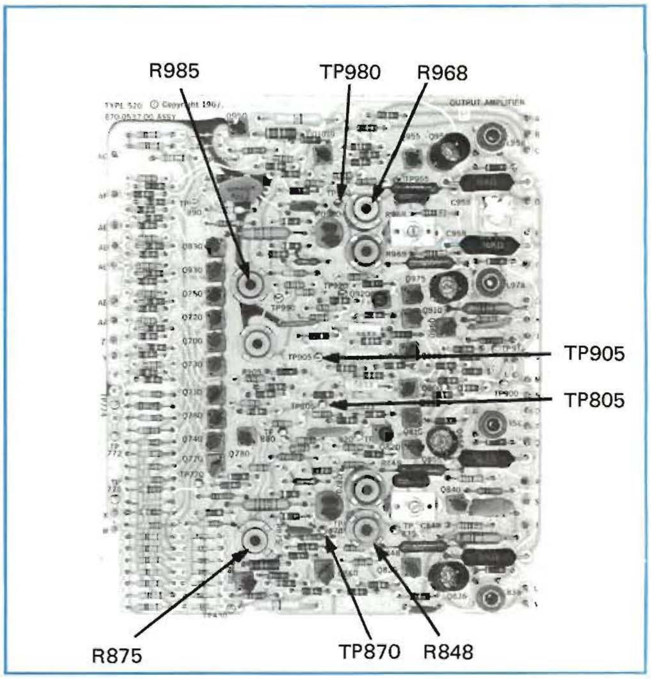
b) Chrominance Gain:
Depress: VECTOR
FULL FIELD
AΦ/BΦALT
Feed composite video from the 140 into CH A and B inputs. You should have two vector displays. Superimpose the vectors using the A and B PHASE controls. Adjust C52 on the Input Amplifier board so the vectors for CH A and B are the same amplitude.

c) CH A and B Phase Difference:
Depress: VECTOR
FULL FIELD
CH A
CH B
Same inputs as in previous step (b). With the A PHASE and B PHASE controls set at 0, the two vector displays should be superimposed. Adjust C88 and C98 located on the back of the PHASE controls so that the vectors are superimposed and the burst vectors are on the 0° reference line.

11) Check the Subcarrier Regenerator Adjustment:
Depress: VECTOR
FULL FIELD
CH A
Feed composite video from the 140 into CH A input. Connect your test scope via a 10X probe to TP255 on the Subcarrier Regenerator board. Set test scope to 0.02 V/div, DC coupled, at a sweep rate of 1 ms/div. Establish a ground reference level on the test scope screen. The DC level on TP255 should be about 0.5 volts and the vector display should be locked in. If the display is spinning, adjust R250 on the Subcarrier Regenerator board until the display locks in. Note the voltage on TP255. Depress A CAL button and observe the voltage on TP255 for a few minutes to see if it drifts. Adjust R250 for the same voltage reading observed when CH A button was depressed. Depress CH A button again and the display should lock in within 15 seconds. Final adjustment of R250 should be set so there is no voltage change at TP255 when CH A and A CAL buttons are alternately depressed. Disconnect the 10X probe and 140 from the 520.



Subcarrier Regenerator Board test point and control locations.



Output Amplifier Board test point and control locations.

12) Check the Output Amplifier Gain:
a) Set Vertical Output Amplifier Gain.
Depress: Y
FULL FIELD
A CAL
You should have the calibrator waveform displayed. Be sure the front panel thumbwheel GAIN controls are in the calibrated position. Adjust R848 located on the Output Amplifier board for 140 IRE Units of cal signal.

b) Set Vertical Driver Amplifier Gain:
Depress: VECTOR
FULL FIELD
CH A
Connect the SIDEBAND VIDEO output of the 067-0546-00 NTSC Vectorscope Test Unit to the CH A input. You should have a circular display. Adjust R626 on the Driver Amplifier board so the top and bottom of the circle line up with the graticule circle.

c) Set Horizontal Output Amplifier Gain.
Depress: Same as Step (b)
Remove the leads from Driver Amp board pins AB and AD. Connect lead from pin AB to pin AD. You should have a horizontal line. Adjust R968 on the Output Amplifier board so the length of the horizontal trace is equal in length to the diameter of the graticule circle. Reconnect leads AB and AD to their respective pins.

d) Set Horizontal Driver Amplifier Gain.
Depress: Same as Step (b)
You should have a circular display. Adjust R646 on the Driver Amplifier board so the circle overlays the graticule circle on the horizontal axis.

13) Check the test circle oscillator amplitude:
Depress: VECTOR
FULL FIELD
A CAL
You should have a circular display. Adjust C18 on the Input Amplifier board so the test circle overlays the graticule circle. Neutralize A CAL and depress B CAL. Adjust C66 on the Input Amplifier board so the test circle overlays the graticule circle.

14) Check the Subcarrier Processing adjustments:
   a) Quadrature Phase Adjustment:
      Depress: VECTOR
               FULL FIELD
               A CAL
      If the adjustment is correct, you will have a circular display that overlays the graticule circle. If not, you will see two circles slightly displaced in phase. Adjust the front panel QUAD PHASE control so the two circles are superimposed. The control should set near mid-range.
   b) Check Demodulator Balance Adjust:
      Depress: I
               FULL FIELD
               A CAL
      Note the position of the horizontal line on the graticule. Depress the DIFF PHASE button and check to see that the horizontal line is within 2 minor divisions of its previous position. Adjust R501 on the Demodulator board if necessary. Recheck step (a) if R501 is adjusted.
   c) Check Demodulator Phase Shift Adjust:
      Depress: VECTOR
               FULL FIELD
               CH A
               Aϕ
      Feed composite video from the 140 into CH A. You should have a vector display. Set the CH A GAIN thumbwheel so the -I vector reaches the edge of the graticule circle. Now hold in the VECTOR button and depress the I button. The vectors should rotate $33° \pm 2°$. For example, the -I vector should be on the vertical graticule line. Adjust L547 on the Demodulator board for optimum phase shift in all four quadrants. Return CH A GAIN thumbwheel to calibrated position.

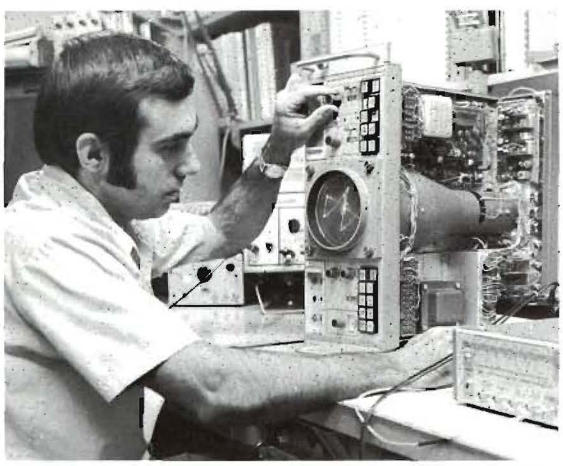
15) Check the Differential Gain Position Balance:
   Depress: Y
            VITS 18
            CH A
   Center the display using the Vert and Horizontal clamp controls. Set CH A VECTORS switch to MAX GAIN position. Depress the DIFF GAIN button and note if the display remains centered. Adjust R498 on the Demodulator board to recenter the display if necessary. Return the CH A VECTOR switch to the 75% position.

16) Check VITS selection of lines 18 and 19 for both fields:
   Depress: Y
            VITS 18
            CH A
   Select VITS line 18 and Field 1 positions on the 140. Set FIELD switch on the 520 to Field 1. You should see a staircase display on the 520. Now select VITS line 19 on the 140 and depress the VITS 19 button on the 520. You should again have a staircase display. Select Field 2 on the 140 and the 520 and check for a stable staircase display. Select VITS line 18 on the 140 and depress VITS 18 on the 520 and check for a stable staircase display.

17) Check the CALIBRATED PHASE adjustment:
   Depress: VECTOR
            FULL FIELD
            CH A
            Aϕ
   Set the 140 for composite video output. Set the CALIBRATED PHASE dial to 0. You should see a vector display. Set the Channel A PHASE control so the "yellow" vector is on the horizontal graticule line. Set the Channel A GAIN thumbwheel so the vector reaches the graticule circle. Now turn the CALIBRATED PHASE dial to +14° and check to see that the "yellow" vector has rotated 7 minor divisions or 14°. Adjust R335 on the rear of the CALIBRATED PHASE control if necessary. Return the CALIBRATED PHASE control to 0. Use CHANNEL A PHASE to set the vector on the horizontal line again. Now turn the CALIBRATED PHASE dial to -14° and check to see that the vector is rotated 14° from the horizontal reference line in the opposite direction. If necessary, adjust L331 on the rear of the CALIBRATED PHASE control. R335 and L331 interact so the +14° and -14° points should be checked after each adjustment.

18) Check the Color Bar Decoding.
   Depress: VECTOR
            FULL FIELD
            CH A
            Aϕ
   The 140 is still feeding composite video into CH A. You should have a vector display. Set the CHANNEL A PHASE and GAIN thumbwheel so the burst lies on the 75% mark on the vector graticule. Depress the R button. Set the sync tip at the -40 IRE Unit level. You should have two bars at the 77.5 IRE Units level. Depress the G button. You should have one large bar at 77.5 IRE Units. Depress the B button. You should have four bars at the 77.5 IRE Units level. The amplitudes of the bars should be nearly the same and within $\pm 3\%$ of the specified amplitudes.

This completes the calibration procedure. Your 520 should now give you reliable measurements of the color signals. If you have difficulty with your instrument, we suggest you contact your TEKTRONIX Field Engineer.



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