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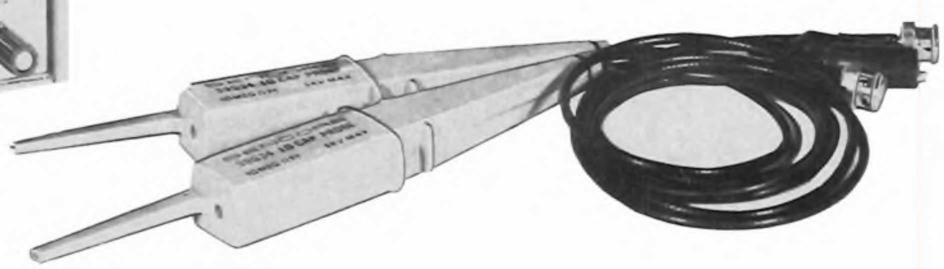
WRITTEN BY
SENCORE FIELD ENGINEERS

PRODUCT of the MONTH

PS163 DUAL TRACE TRIGGERED OSCILLOSCOPE



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10 Most Often Asked Questions About Oscilloscopes

Ramer Streed

Design Engineer

There are probably a hundred different oscilloscopes available today. They range from low cost limited application instruments to very high priced, sophisticated lab instruments. Which one is best for your application? How important is price? Should you buy a conventional or triggered scope? Single or dual trace?

We are using this issue introducing our all new PS163 dual channel, dual trace triggered sweep oscilloscope, to try to answer some of these questions and help clarify scope features and specifications for you. Ramer Streed, the project engineer for our PS163, and the Field Engineering department have put our heads together to try to provide the answers you need for these important questions.

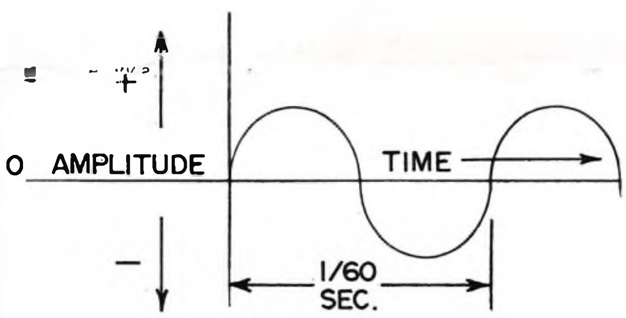
We are sure you will find the topic of oscilloscopes interesting and informative, and suggest that you try at least one of the two fine Sencore oscilloscopes featured in this issue. You are certain to find them a valuable asset in your work.

Norm Pedersen

Chief Field Engineer

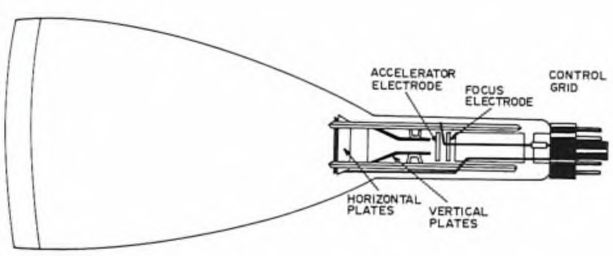
1 WHAT IS AN OSCILLOSCOPE?

Although the oscilloscope has been playing an important part in electronics for years, we are still asked many questions about the basics of scopes and their uses. The scope, in virtually any form used, is an electronic graph displaying or plotting some action with respect to time. An example which is quite familiar to most of us is the display of a 60 cycle AC sine wave shown here.



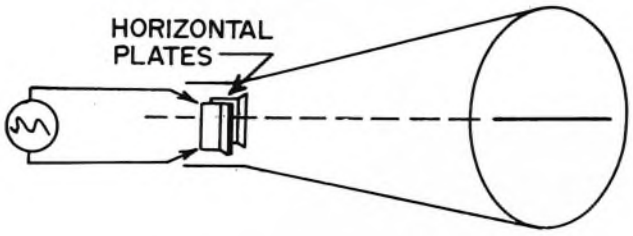
The display shows graphically the voltage changes which take place during a certain interval of time. The graph shows how the signal voltage begins its cycle at 0 and moves in an upward or positive direction to a maximum peak. The voltage then begins to decrease or move in a downward direction until it returns to zero. The voltage change continues until the negative peak is reached and then the voltage returns again to the zero level. This completes one cycle of change. If the time necessary for this cycle to take place were measured, it would be found to be one sixtieth of a second. The graph then shows the changes in voltage occurring in the time of 1/60 of a second.

The need to be able to "see" the changes which take place in electric and electronic circuits fathered the concept of today's modern scopes. One of the keys to the scope, which gives us "eyes" to look into electronic circuits and "see" the action caused by electron movement, is the Cathode Ray Tube or CRT. The cathode ray tube used in most scopes consists of an electron gun, to produce an accelerated stream of electrons

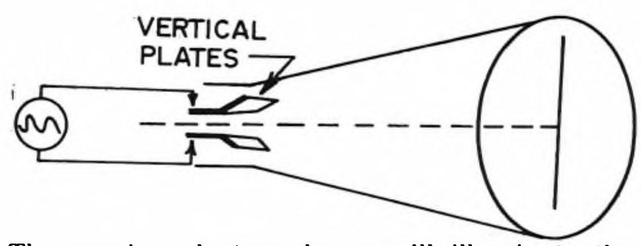


usually called the beam, deflection plates to position or move the electron "beam", and a phosphor coated glass faceplace which is illuminated when struck by the electron beam. (The drawing shows the basic CRT used in oscilloscopes.)

The electron gun consists of the electron source, (cathode), a controlling element (control grid), and an accelerating electrode (screen grid) which also provides focusing. The deflection plates are placed parallel to the beam path, one set on either side of the beam path and one set above and below the beam.



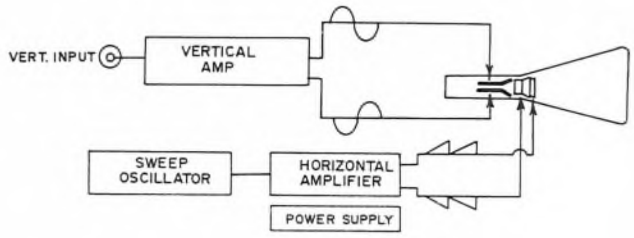
The plates on either side will cause the beam to move from side to side when a changing voltage is applied to the plates. This electrostatic deflection is also used to provide vertical beam movement when a changing voltage is applied to the plates above and below the beam.



The moving electron beam will illuminate the phosphor on the CRT faceplate and show the beam "path" caused by the deflection. The "persistance" or lingering illumination of the phosphor allows the path of this beam to be seen as the beam travels the same path repeatedly.

THE SYSTEM

Other components are needed to complete a system which will provide beam deflection and control, and make the CRT useable. An amplifier is normally employed in series with the vertical deflection plates to provide sufficient signal level to produce beam movement. This amplifier should be distortion-free to amplify the vertical input signal without changing it. The horizontal deflection plates must also be supplied a signal of sufficient amplitude to move the beam from side to side. This signal is usually produced by an oscillator to obtain a controlled rate of repetition.



The continuous movement of this beam across the screen is termed "sweep". The sweep across the CRT at a controlled speed produces the "time" portion of our electronic graph. The oscillator signal is normally a sawtooth shape to produce a constant speed for beam movement across the screen, and rapid return or retrace to the starting point. A power supply must also be employed to provide the power necessary for CRT and amplifier operation. Additional circuits must also be used to provide synchronization between the input signal and sweep signal, and to produce return sweep blanking.

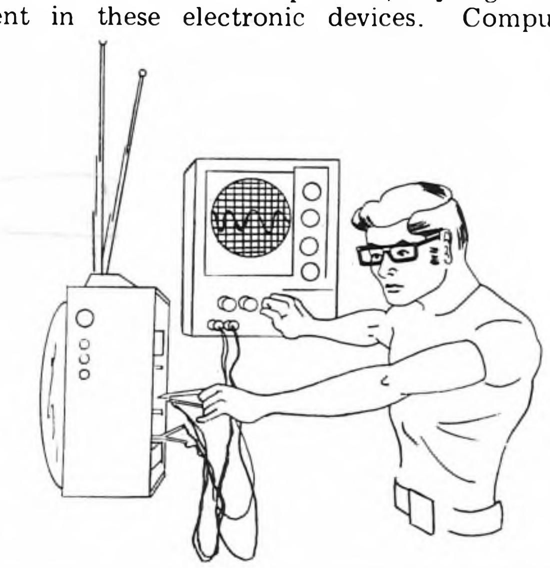
THE CONTROLS

The controls on the oscilloscope are used to adjust for desired operation of the amplifier and CRT. The vertical gain or amplitude control or controls are used to vary the height of vertical display. This is done by either varying the amount of input signal or by changing the amplifier gain. The vertical position control changes the DC voltage at the vertical deflection plates and allows the trace to be positioned vertically on the CRT face.

The horizontal frequency (or sweep frequency) controls determine the frequency of the internal oscillator and thus the sweep speed, or rate of beam movement horizontally. The horizontal gain control varies the gain or signal level to the horizontal plates to change the length of trace or sweep width. The horizontal position control changes the DC voltage to the horizontal deflection plates and allows the beam to be positioned horizontally on the CRT screen. The focus control changes the accelerating voltage to the screen grid to produce a small, sharp spot when the beam strikes the CRT phosphor. The brightness control varies the bias between the cathode and control grid to determine the intensity of the electron beam.

THE USES

The scope has uses and applications in any area dealing with electricity or electronics. The scope gives us the tool necessary to study the effects and actions of an electronic circuit. It in effect becomes a window to the invisible, mysterious world of electronics. Radio, stereo, and TV designers, engineers, and service technicians all have need to observe the important, key signals present in these electronic devices. Computers,



The scope is a key tool to the electronic service technician electronic control circuits and devices have many primary signals present which must be monitored and observed to assure correct function and operation. The oscilloscope is also used in high schools, colleges, vocational schools, and universities, to aid in teaching and understanding electronics.

It is also used in other fields, such as medicine for heart or pulse monitoring, and in the automotive industry to observe the operation of the automotive ignition system.

Regardless of the application, the scope is providing a representation, in the form of a graph, of some electronic action with respect to time.


The scope provides essential information on heart condition during operations.


Professional auto mechanics make use of the scope for ignition work.

2 WHAT FREQUENCY RESPONSE SHOULD THE SCOPE HAVE?

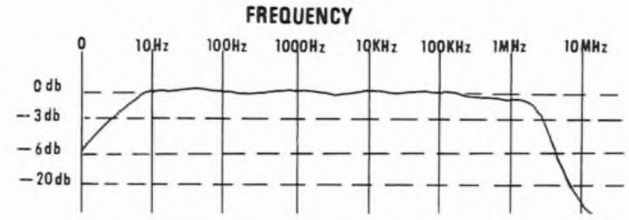
Each application for the scope will require somewhat different frequencies to be amplified and applied to the CRT plates. A scope used for heart monitoring would have to be able to pass and amplify primarily low frequencies. A scope used just for radio work needs the capability of amplifying frequencies from near DC to 20,000 hertz. Television service and maintenance personnel require a scope which can easily display frequencies from 30 hertz to over 4MHz to enable observation of all signals involved. The design engineer for a television manufacturer will probably require a scope which can display signals above 40MHz to thoroughly test the receivers.

The frequencies which can be displayed on the scope CRT are determined largely by the design of the vertical amplifier and the range of sweep frequencies available. A scope with 10MHz bandpass may sound impressive, but if the fastest sweep speed is only 200KHz the vertical bandpass is useless. The slow sweep speed will not allow frequencies of 10MHz to be observed. Be sure to consider both points in your selection of a scope.

In order for an oscilloscope to be produced economically, the needs of several different areas are usually incorporated in a general purpose oscilloscope. The Sencore PS148 is such an instrument.

PS148 general purpose oscilloscope.

The vertical amplifier has been designed to amplify all signals equally from 5 hertz to 5.2MHz. This is called the bandpass of the scope, and is an important specification. This indicates the frequencies which can be applied to the input and will be amplified without distortion and displayed on the CRT. The bandpass of a scope is usually stated as the range of frequencies within the 3db points or the points where the gain of the amplifier is reduced 30% below maximum. The PS 148 provides the necessary bandwidth (from 5Hz to 5.2MHz) for most servicing, industrial and educational applications. The graph shown here shows the response of the PS148. You will note that its response extends well above the color frequencies at 3.58MHz which are normally the highest frequencies encountered in servicing and maintenance.

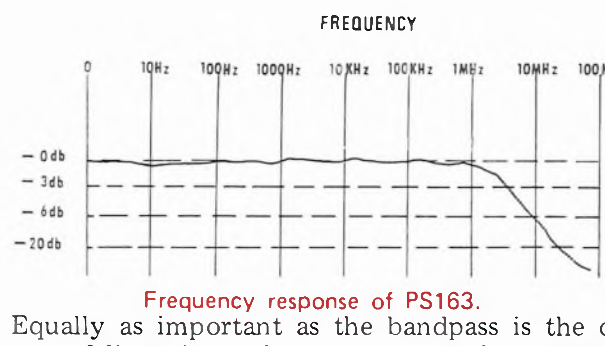


Frequency response of PS148.

The new PS163 dual trace triggered oscilloscope is also a general purpose scope, but employes two separate amplifiers, one for each trace. Each amplifier has the capability of amplifying, within the 3db limit, frequencies from DC to 8MHz.

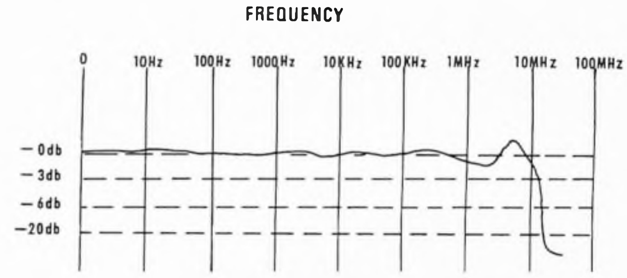
PS163 Dual trace triggered scope.

This bandwidth covers all applications from low frequency audio work to the highest chroma frequencies in color TV. The PS163 fills the requirements of all but a few specialized areas which require a special oscilloscope built specifically to fill certain unusual needs. Even though the 3db limits are 5.2MHz and 8MHz respectively on the Sencore scopes, they are useable at much higher frequencies. The broad band amplifier of the PS 163 is useable to frequencies of 15MHz or higher. Again we will use a graph so you are able to see the actual response of the scope.



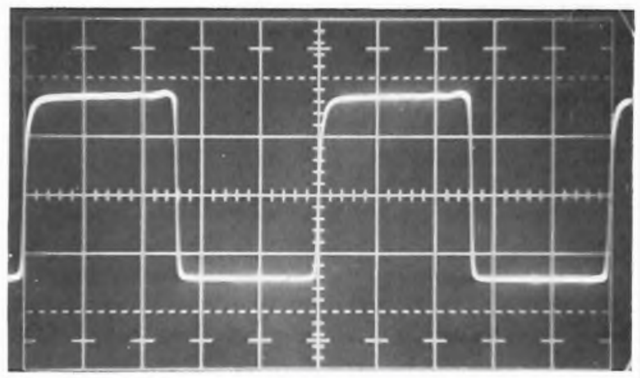
Frequency response of PS163.

Equally as important as the bandpass is the degree of distortion and overshoot introduced by the vertical amplifier. Many scopes which claim bandpass specifications to 10 or 15MHz will not always give faithful reproduction of these high frequency signals, if they are other than sine wave signals. Some will even introduce distortion on much lower frequencies. Many signals you need to check are not sinusoidal, such as TV video and sweep signals, and the scope must be capable of displaying these as accurately as sine waves. Let us take a close look at the frequency response curves for these scopes. The response shown here is from an imported scope with stated frequency response to 10MHz. As you can see, the frequency response does extend to 10MHz (on sine wave signals) but drops off very rapidly above this point

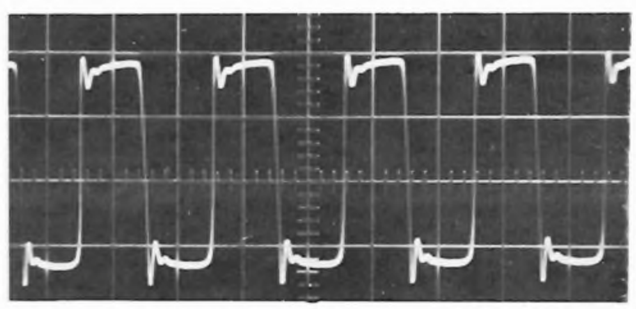


Response of imported 10MHz scope.

Compare this to the gradual, linear roll-off of the Sencore PS163 shown above. The overshoot problem develops on instruments such as the lower priced 10MHz scope because peaking coils are used to attain the wide bandpass. The sharp dropoff of the response and the peaking coils create a damped oscillation on any signals with sharp wavefronts or fast rise times. Peaking coils are not used in the PS163 so ringing is not present. The gaussian rolloff of the PS163 response allows all the harmonics to be amplified without phase shift, including those which may extend well above 15MHz, giving a true waveform reproduction without ringing or spiking on the leading and trailing edges. A 1MHz square wave can be used to prove our point.

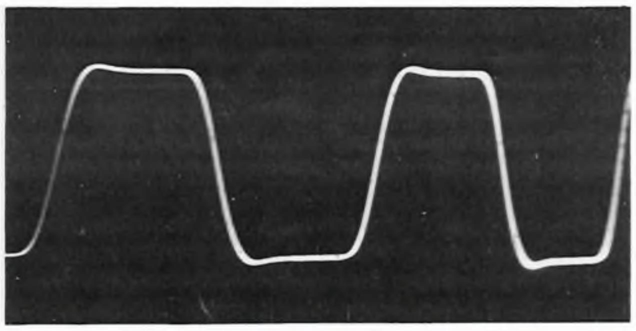

1MHz square wave on $3000 80MHz scope.

The first photo shows the display obtained with high quality high priced lab type scope with ability to amplify and display signals up to 80MHz. The input signal is a square wave at the frequency of 1MHz. The square wave is displayed clean without any distortion or ringing. The second photo is the same signal displayed on an imported triggered sweep scope claiming 10MHz bandpass. The input signal of 1MHz is only 1/10 the frequency bandpass of 10MHz claimed in the specifications.


Distorted response on imported 10MHz scope caused by over peaking

Notice the pronounced overshoot or ringing present on the signal. This overshoot makes waveform analysis difficult as the display does not accurately represent the input signal.

The third photo shows again the 1MHz square



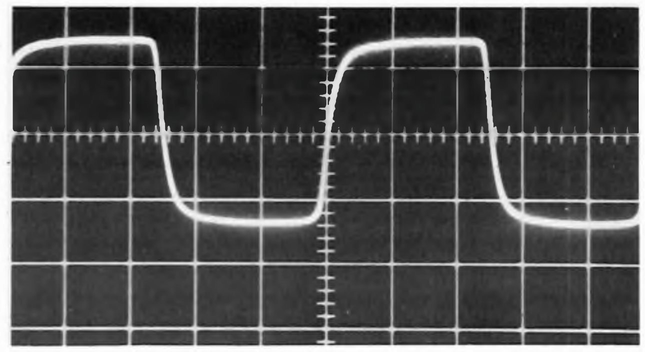
1MHz square wave on Sencore PS148.

wave, this time displayed on the Sencore PS148 General Purpose Scope, costing $150 less then the 10MHz scopes.

The square wave presentation is far more accurate and will permit meaningful troubleshooting and waveform analysis.

The last photo shows the 1MHz square wave as seen on the PS163. The display is clean and sharp, and accurately displays the square wave without any ringing or overshoot.

Be sure you consider not only the bandpass needed for your application, but the overshoot as well, if you want accurate waveform presentation. The overshoot should be 1% or less if the scope is to produce the best and most accurate display on all types of waveforms. The Sencore PS163 has been designed to provide true 8MHz response without



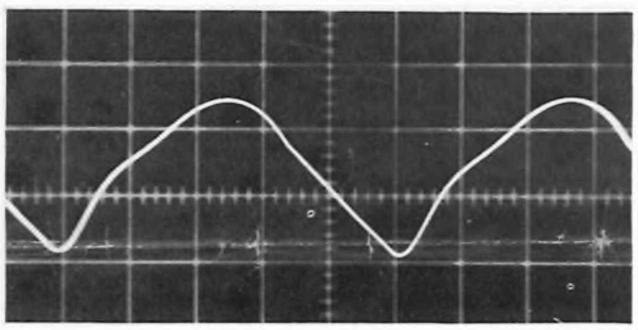
1MHz square wave shown on PS163.

peaking coils to assure no overshoot. Weigh carefully the true bandpass of the scope you buy to be sure you are getting the best value. Remember, a few extra dollars spent for a quality instrument may be the best investment you have ever made.

3 WHAT SWEEP SPEEDS ARE NEEDED?

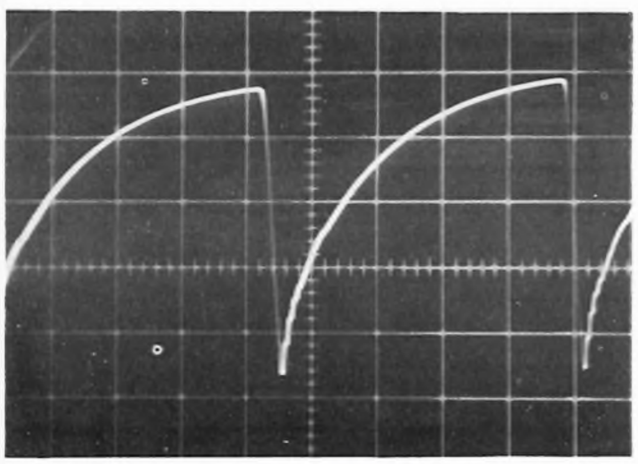
The sweep speeds necessary on the oscilloscope are determined largely by the application and frequency requirements of the signals to be observed. Let's look at some of these requirements for a moment.

For best observation of a waveform or signal, most persons using the oscilloscope prefer to see from 2 to 5 cycles of the waveform displayed. When working on an audio amplifier, to check its response at 20 Hertz, the sweep speed of the oscilloscope should be 10 Hertz to display two complete cycles of the audio signal. If we want to see 2 cycles of the output ripple from a half wave rectifier type of power supply, the sweep speed needed is 30 Hertz.



60Hz AC ripple is present in many power supplies.

The ripple frequency of 60 Hertz will then be displayed as 2 cycles on the screen of the CRT. If the power supply is full wave, and we again wish to see 2 cycles of ripple, the sweep frequency would have to be 60 cycles.

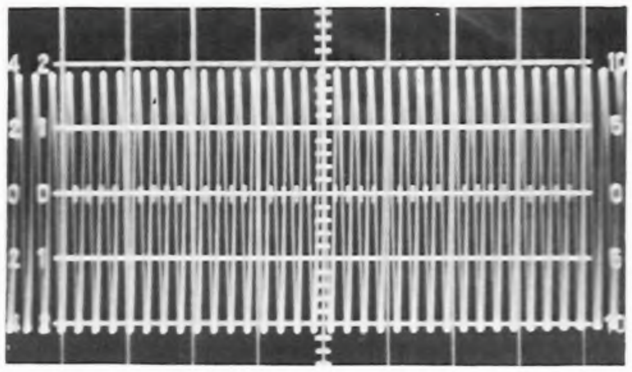


Horizontal sweep waveform is key signal.

The horizontal signals present in television receivers are common waveforms observed by the service technician. The horizontal frequency of 15,750 Hertz means the scope sweep frequency must be 7875 Hertz to display 2 cycles. Much higher signal frequencies are also present in television receivers. The 3.58MHz color sync and color oscillator signals must be present and correct in a color receiver to obtain a good quality color picture. The sweep speed of the oscilloscope should be at least 500KHz if the 3.58MHz signal is to be displayed clearly so it can be analyzed. Some scopes offer sweep speeds of only 100KHz or less which will display no less than 35 cycles of color information as shown here.

Signal analysis is extremely difficult due to the large number of cycles displayed.

If you wish to make any meaningful waveform

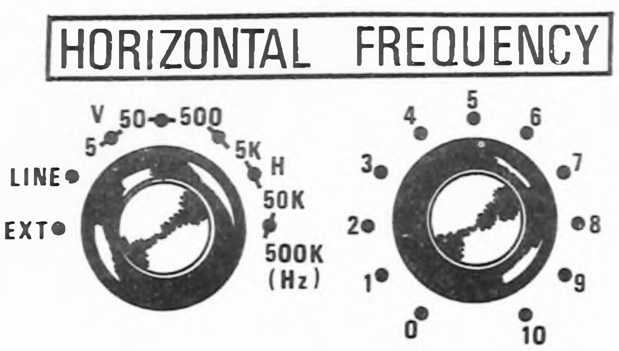


3.58MHz color oscillator at fastest sweep rate of imported triggered scope.

analysis, a higher sweep speed is necessary in order to reduce the number of cycles on display. You should be sure that the scope you consider can produce sweep speeds of at least 500KHz for close observation of critical color waveforms.

Another important servicing function is the alignment of television receivers. A scope must be used to monitor the results of the various adjustments. The scope used for this purpose should have 60Hz line sweep rate as well as external sweep capabilities to adapt to all of the various kinds of sweep equipment

The Sencore PS148 has been designed with bandpass and sweep speeds necessary for close and accurate observation of signals and waveforms present in radios, stereos, and television receivers. It provides sweep speeds from 5Hz - 500KHz in 5 overlapping ranges, with a vernier control for fine frequency adjustment, plus 60Hz and EXT sweep



Full sweep ranges are provided on PS148.

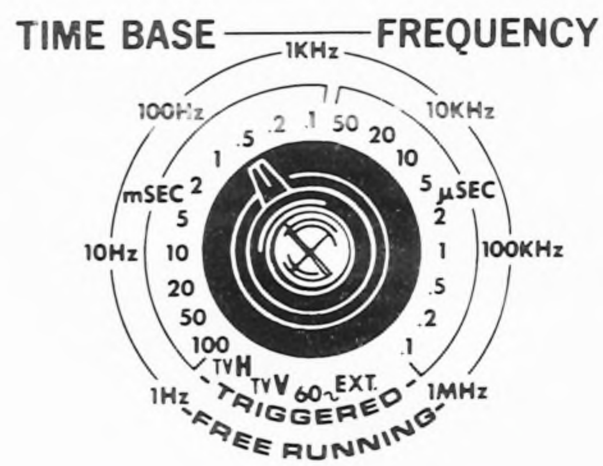
positions. The Sencore PS148 will give you an accurate, stable display from the low audio frequencies all the way up to the high frequencies present in the chroma circuits of a color television receiver, and it is priced within anyone's budget. At only $269.50. the PS148 is a great value.

If you have need for a new oscilloscope, be sure to consider the specifications and price of the PS148 before you decide.

Triggered sweep scopes normally list the sweep speed in "time per division or centimeter".

The sweep frequency is the reciprical of this time period. For example, if the time base or sweep speed is set at 1 millisecond per division and the scope grid has 10 horizontal divisions, it will require 10 milliseconds to sweep across the screen. The sweep frequency is then the reciprical of 10msec $\frac{1}{(.01sec)}$ or 100 Hertz. If the time base of a triggered sweep scope covers a range from .5 second to .5 microseconds, as many of them do, the range of sweep speeds is from .2Hz to 200KHz. The 200KHz rate is not fast enough for convenient color servicing as it will display 17 cycles at the 3.58MHz color frequencies. Again the sweep speed should be at least 500KHz or .2 microseconds per division.

The PS163 by Sencore provides sweep speeds from .1 second to .1 microsecond per division or from 1 Hertz to 1MHz. This means you can display just one cycle of a 1MHz input signal and 3 cycles of the color oscillator signal. If higher signals are to be observed, a 5 times expand feature raises the sweep speed to 5MHz! Imagine being able to see less than one cycle of the 3.58MHz color oscillator signal. The PS163 will do it!



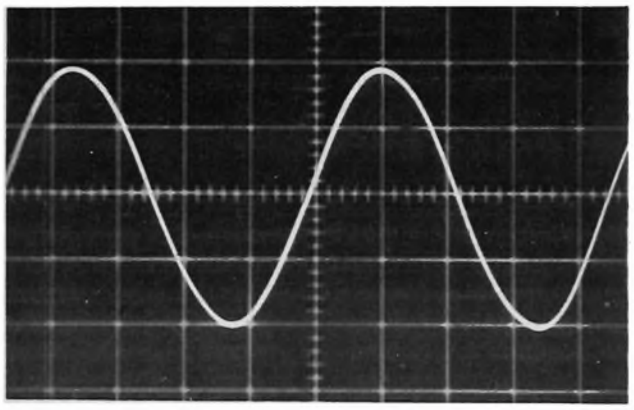
PS163 covers all needed sweep rates plus special TVV, TVH, 60Hz and EXT sweep.

The time base control of the PS163 provides 23 positions covering the frequency range mentioned and includes special preset TV vertical and TV horizontal positions for viewing television waveforms. Line and external sweep positions are also provided for use with sweep generators needed for complete TV service. Another feature of the PS 163 is the listing of the sweep frequency on the front panel as well as the time base. This removes the confusion sometimes resulting when time base only is given.

The Sencore PS163 has been designed with the needs of the user in mind, and provides the coverage needed and wanted for servicing, design, and educational applications; and its all American made.

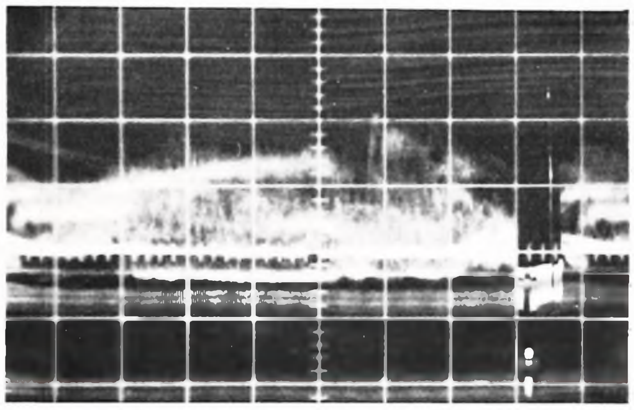
Let's now take a look at some of the common scope applications to show the advantage of 23 time base positions and the type of display capable on a PS163. First, we'll look at the low audio frequencies found in HiFi and Stereo applications.

The waveform shown is a 20 Hz sine wave in an audio amplifier with the time base set for 10 msec per division. The display is sharp and steady even at these low sweep speeds.



10msec time base clearly displays 20Hz audio signal

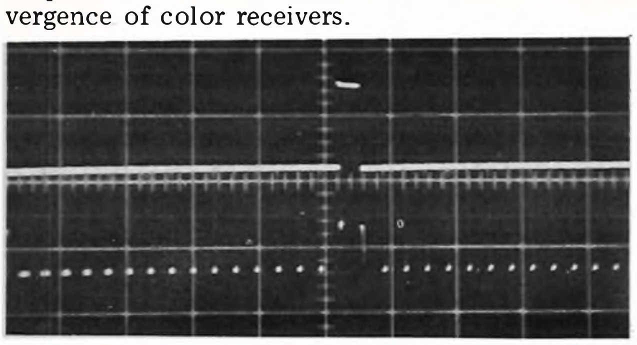
A very common display seen on the oscilloscope by television service technicians is the video signal at the vertical sync rate of 60 Hz.



Sharp, clear video display on PS163 aids troubleshooting.

For this display, the time base is set to the TV Vertical position which is preset to display one cycle at the vertical sync rate. A clean, stable display of the composite video signal is a must when servicing television receivers and the PS163 does it with unequalled ease.

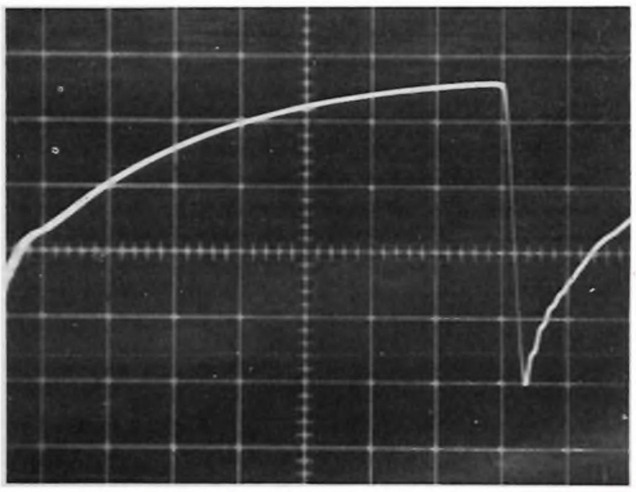
Next, we will look at a signal important to a test equipment design engineer; The 900Hz pulse signal present in a color bar generator. It is used to produce the horizontal lines needed for convergence of color receivers.



.2msec rate allows easy viewing of 900Hz signal.

The time base is set for .2msec per division or 500Hz. You can be sure that an oscilloscope such as the PS163 is a very valuable and necessary tool to the design engineer or technician during the development and testing stages of products such as the color generator.

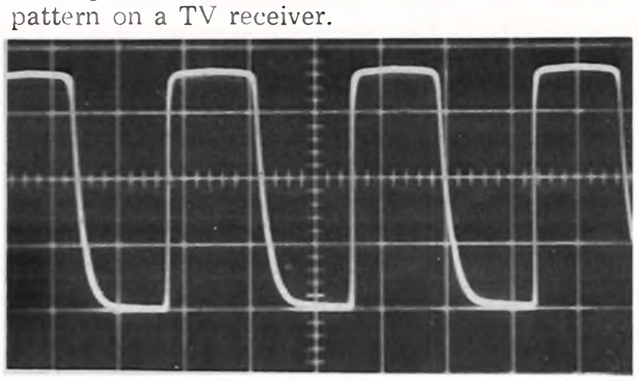
Another key signal to the television service technician is the signal present at the grid of the horizontal output tube.



The TVH position with sync separator makes television troubleshooting easier.

The shape and amplitude of this signal, and other horizontal pulse signals, has much to do with the proper operation of television sweep, high voltage, AGC and chroma circuits. This display is shown with the time base switch in the TVH position, preset for observing signals at the 15,750 horizontal frequency. The two preset positions for TV vertical and TV horizontal waveform viewing, make the PS163 extremely fast and easy to use for television servicing.

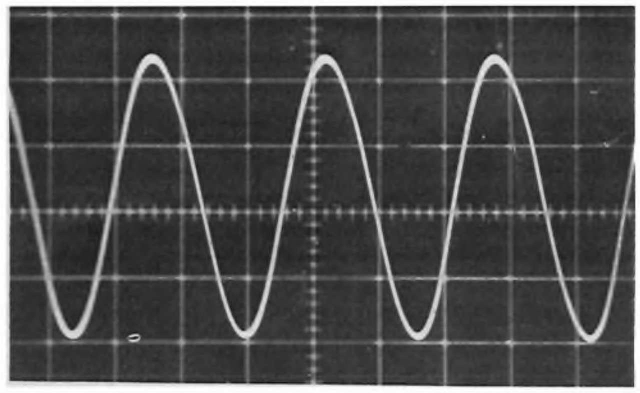
The next signal we checked was that found in a color generator used to produce the vertical line pattern on a TV receiver.



189KHz oscillator signal is seen easily with 2uSec time base setting.

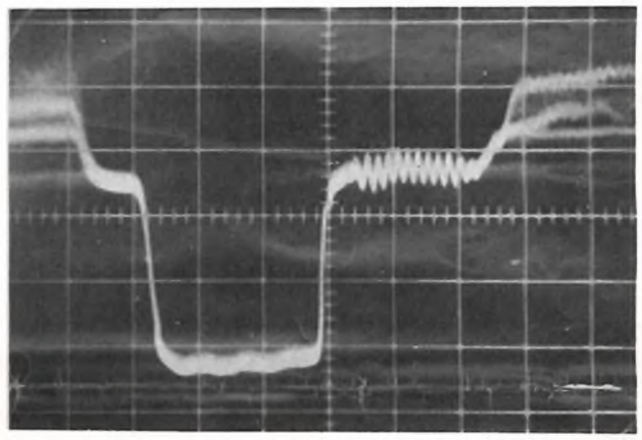
The frequency of this signal is 189KHz and the time base is set to 2 microseconds per division to obtain the clear waveform shown.

The last two photos were taken with the PS163 connected to observe signals in the chroma circuit of a color receiver. The first photo shows the signal output of the 3.58MHz oscillator with the time base set for .1usec per division.



Viewing signals in color circuits is a must for TV servicing.

The PS163 really stands out from other scopes when viewing these high frequencies because of the increased range of high sweep speeds incorporated for this purpose.

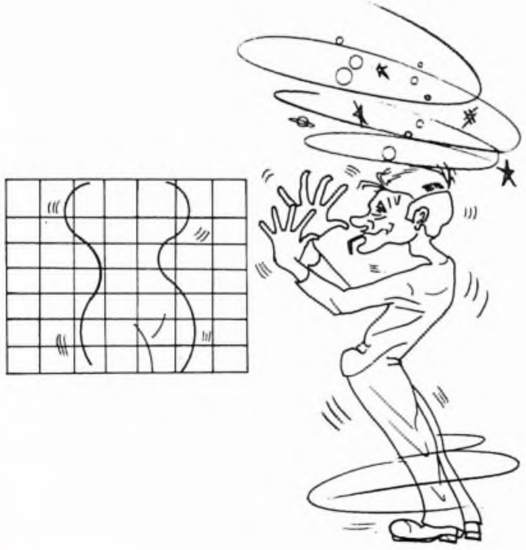


5X expand allows close waveform observation.

The last of this series of waveforms is the back porch of the horizontal blanking pulse showing the burst signal being transmitted from the TV station. This signal is easily observed with the time base set to 20 microseconds/Div and the 5X expand feature used to spread this area of the waveform. As you can see, the PS163 covers all the needed sweep speeds and produces waveforms so stable that even the fast eye of the camera does not pick up any faults. The PS163 is truly the scope to fill all your needs and at a price you can afford.

4 HOW DO YOU GET THE PATTERNS TO HOLD STILL?

Have you ever attempted to measure or observe a waveform and couldn't get it to stop running by on the CRT? You probably have and this creates a real problem for you because the pattern must be maintained stationary to observe, measure, or analyze the waveform.

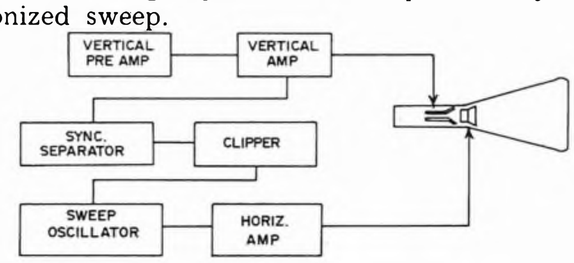


Unstable sync can cause misinterpretation of waveforms.

The service type oscilloscopes in common useage generally have a sync circuit which is used to control the frequency of the free running sweep oscillator. The sync circuit is usually fed a sample of the input signal to process for use in synchronizing the sweep frequency with the frequency of the incoming signal.

The type of oscillator used and the manner in which the sync circuit controls the oscillator is most important in obtaining a good, stable trace.

Sencore engineers have studied this problem carefully and have utilized sync and oscillator circuits designed to provide the ultimate in waveform stability. The PS148 uses a phantastron oscillator and a two stage sync circuit to produce synchronized sweep.

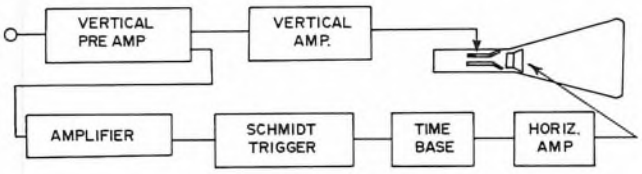


Stable sync is provided on the PS148 by well designed sync and oscillator circuits.

The action of this circuit produces a sweep signal which is "semi-triggered" making it easier to operate and as stable as many of the triggered sweep scopes. A sync selector switch provides internal, line or external sync to give you a rock solid display on any input signal. The sync phase control allows sync level adjustment for either positive or negative going input signals. If your needs call for a low-cost service type oscilloscope with solid sync, you won't be able to beat the Sencore PS148.

The PS163 is a full triggered oscilloscope and uses the sync signal to trigger or initiate the sweep cycle. To be sure we all fully understand the operation of a triggered scope, let's take a couple of minutes and run through it together. The sweep circuits of a triggered scope will be inoperative and the CRT blanked until the proper pulse is applied to the sweep circuit. When the correct pulse is received, a "one-shot" type of circuit goes into action, unblanks the CRT, produces one cycle of sweep and resets to the "off" state. Sweep will not reoccur until another pulse of correct amplitude and polarity is applied to the sweep circuit.

The circuitry of the PS163 uses a sample of the input signal taken from the preamplifier stage to provide the sweep trigger pulse. This signal from the input is fed to a high gain amplifier called a differential comparitor.



Reliable sync is provided by circuits of PS163.

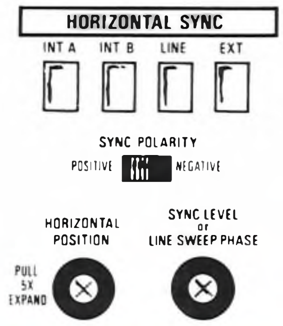
This amplifier also has a DC reference voltage applied to establish the point at which the amplifier will conduct. If this bias voltage is set to the proper level, and the input signal has the correct polarity and amplitude, it will cause the amplifier to swing between cutoff and saturation producing a modified square wave output. This output is further squared by a Schmitt trigger and is used to trigger the sweep circuit. The trigger or sync level control changes the DC reference voltage and the operating point of the amplifier. The sync or trigger polarity (or slope control as it is called on some scopes) determines whether the amplifier reacts to a positive or negative going signal. The PS163 uses this form of simple, positive sync circuits to provide easy, dependable operation.

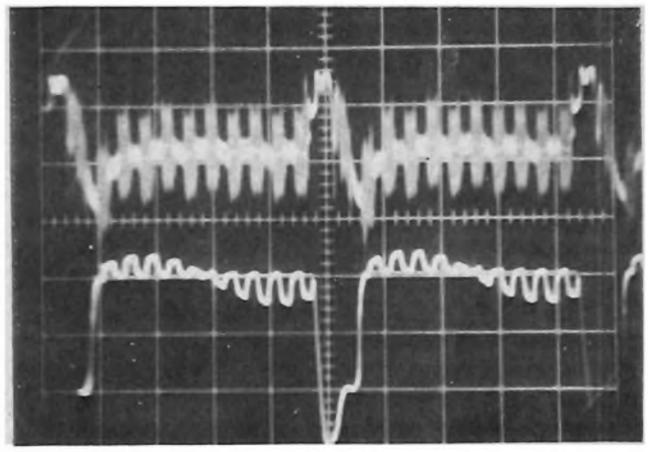
The triggered scope is considered by many to be more stable than the service type recurrent sweep system. This may be true in many instances, but there are situations when the triggered sweep scope comes in a poor second to the service type scope. One of these cases is the observation of the complex video signal present in television receivers. The normal time base frequency of triggered scopes does not always provide a sweep speed which can be easily used to display the video signal.

The average triggered scope also has difficulty in deciding which field to use for triggering, and, as a result, the display will be unstable and jittery. This problem is overcome in the PS 163 by adding special sweep ranges and a television type sync separator for the TV vertical and TV horizontal sweep frequencies. These are preset to give you rock solid display of these all important signals. No muss, no fuss, no bother; just set the time base switch to either TVV or TVH and the signal pops into view on the CRT so solid you'll think its glued there.

Another exclusive feature of the PS163 is the selectable trigger or sync source. Most dual trace oscilloscopes use a mixing circuit to develop the triggering signal for the sweep circuit. If the signal is applied only to channel A or channel B this then is the only signal which will be sent to the trigger circuits to provide the initiation of the sweep cycle. The disadvantage of such a mixing circuit is noticed quickly when two signals of the same frequency, such as the video signal and the chroma signal of a TV receiver, are viewed at the horizontal sweep frequency. The mixing does not provide a consistant sharp triggering signal and as a result, the sweep triggers at somewhat different points for each successive sweep. The result is a "jitter" or "double-triggering" giving an unstable or blurry display.

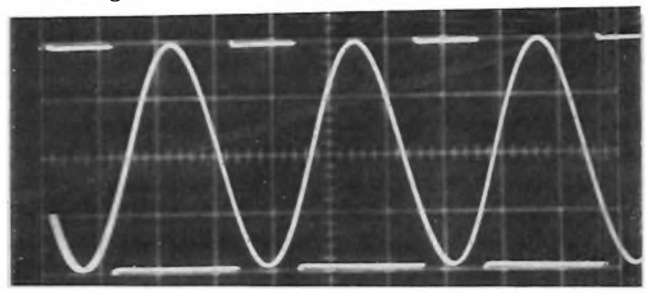
The source of sync information on the PS163 is controlled by front panel push button switches clearly labeled for easy identification. Being able to select the input signal to be used to trigger the sweep, either channel A or B, assures sharp, stable displays without jitter, even on similar complex signals as shown here.





Solid sync on complex signals is a valuable feature of PS163.

The independent selection of trigger source offered on the Sencore PS163 also allows the waveforms being displayed to be superimposed for accurate comparisons. The loss of triggering which occurs on some scopes when the signals are viewed in this manner does not occur when you are using the PS163.



Waveform comparisons are easy with sync stability of PS163.

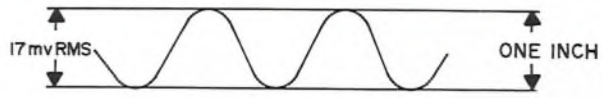
You should begin to see why we feel the PS163 represents one of the greatest values in scopes today. It is a "lab" type scope offering full features, yet is priced just a few dollars more than service type instruments.

5 WHAT AMOUNT OF SIGNAL IS NECESSARY FOR DISPLAY?

The amount of input signal necessary to obtain a display is controlled by two main factors. Obviously, you must have enough input signal to produce a trace of useable amplitude on the CRT if you are to do any waveform analysis. The second factor is the level of input signal required to produce solid sync. Unless the waveform can be held stationary, the display has little meaning. The sensitivity of the vertical amplifier circuitry has the greatest influence on both these conditions. The sensitivity of a scope is usually stated as the level of input signal necessary to produce a display of specific amplitude on the CRT. This can range from extremely sensitive inputs on special application instruments to a very low sensitivity on low cost training or kit equipment.

The sensitivity needed in the vertical amplifiers is largely determined by the intended use or application of the scope. If the smallest signal you will need to measure is 5 volts peak to peak, the scope really doesn't need a sensitivity of 25mv p-p. The reverse situation is what can really cause problems. For instance, you need to check a signal at 5 millivolts peak to peak and the scope sensitivity is 5 volts peak to peak. The signal input is so small that a useable trace cannot be obtained. This situation makes the scope useless for any practical testing or analysis. The level of input signal required for you to obtain a useable, stable display therefore establishes the input sensitivity of the vertical amplifier.

The service type scope will normally have an input sensitivity between 15 and 50 millivolts RMS per inch. This figure means that to obtain one inch of deflection, a signal of amplitude equal to or greater than the input sensitivity must be applied. The PS148 is designed to provide 1 inch of vertical deflection with an input signal of 17 mv RMS. The smallest signal which can be coupled to the input and still obtain the one inch deflection would be 17mv RMS or 48mv p-p.



ONE INCH WAVE FORM

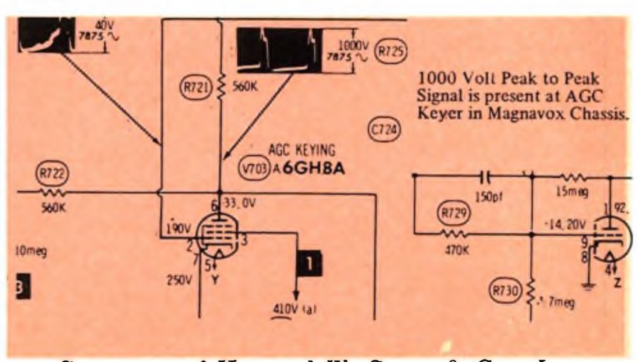
This signal level, or greater, will provide adequate display for analysis and will give solid sync for a steady display. Lower signal levels may be displayed as well, but the height of the display will be decreased and synchronization will become more critical.

How does the PS148 compare to triggered scopes for sensitivity? This question is being asked of us frequently as the "triggered" scope is being emphasized more and more by manufacturers in advertising, and in magazine articles. Let's take a moment to make some comparisons. The sensitivity of most triggered sweep scopes is stated in volts per centimeter rather than volts per inch as is the PS148. This may cause you to believe the PS148 is less sensitive when you begin to compare specs. This is certainly NOT the case. To make a true comparison, we must first convert one of the specs so we are comparing on the same basis, either inches or centimeters for both instruments. Therefore, if we assess the triggered scope on a sensitivity per inch basis, we will be able to make a direct comparison with the PS148. Let's use the sensitivity of 20mv pp/cm which is common to many of the lower priced triggered scopes. 2.54 centimeters are required to equal 1 inch. 20mv x 2.54 (to convert from centimeters to inches) gives us a figure of 51mv. This is the peak-to-peak signal level input needed to obtain one inch of deflection on a triggered scope with 20mv cm sensitivity. The PS148 requires only 48mv pp per inch so it is more sensitive than the triggered scope. In addition, it has faster sweep speeds, and is much lower priced. These are important facts to consider before your purchase.

The PS163 has an input sensitivity of 5mv per centimeter. This is 2 to 4 times greater sensitivity than most triggered scopes including those priced many times higher than the PS163. High sensitivity such as this permits easy waveform analysis in low level circuits such as many of the solid state circuits being used today.

Another important point to consider when purchasing a scope for servicing is the maximum voltage which can be applied to the scope input without damage. Many signals of very high amplitude are present in TV receivers. Signals such as those present at the horizontal output and damper stages reach levels of 4,000 to 6,000 volts peak-to-peak. Vertical output pulses are in the neighborhood of 1000 to 1200 volts peak to peak. You may not normally measure these signals, but what happens if you should accidently make contact with these pulses? What is the maximum input voltage the scope is capable of withstanding? If you check specifications on other scopes, you will find the maximum input voltage rating is 600 volts peak to peak or less.

Contact with a high vertical or horizontal output pulse, or even B+ boost in a color set, will damage and disable these scopes. You may be very careful and cautious when you service and not consider this important but let's be honest with each other. Accidents can, and do happen! Also, a 600 volt input rating gives you another handicap. Some sets use a 700 to 800 volt flyback pulse to the AGC Keyer, which you can't measure with these instruments.



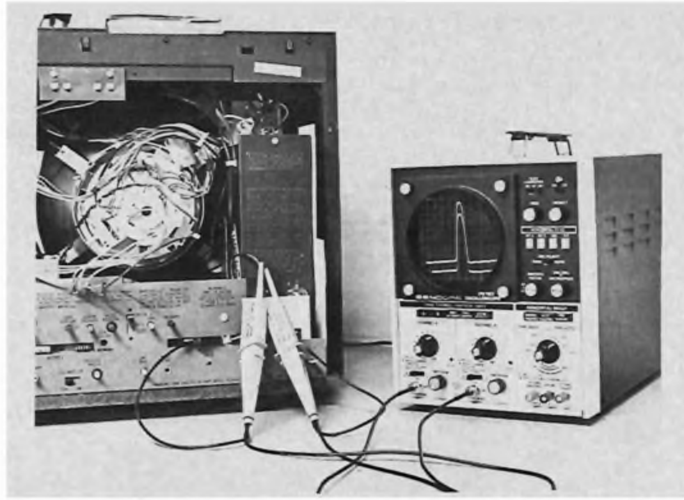
Courtesy of Howard W. Sams & Co., Inc.

WHAT ABOUT THE PS163

Sencore engineers considered these points very important when designing both Sencore scopes.

The input rating of the PS163 is 5,000 volts peak to peak using the low capacity probe; and 7,000 volts on the PS148 using the low capacity probe. Every unit is checked on the production line by connecting the probe to the horizontal output of a color receiver with over 7,000 volts present.

The PS163 also has a very sensitive trigger circuit which will provide rock solid display with vertical deflection of one centimeter or less! This means that the PS163 will be able to display and trigger on input signals as small as 5mv. According to Ramer Streed, the project design engineer, this sensitivity was designed into the PS163 to overcome a major drawback of many other triggered scopes. "When you are working in solid state circuits, there are many instances when the signal present will be as low as 5mv. You must be able



Zero Defects department fully tests all instruments for proper operation and overload protection.

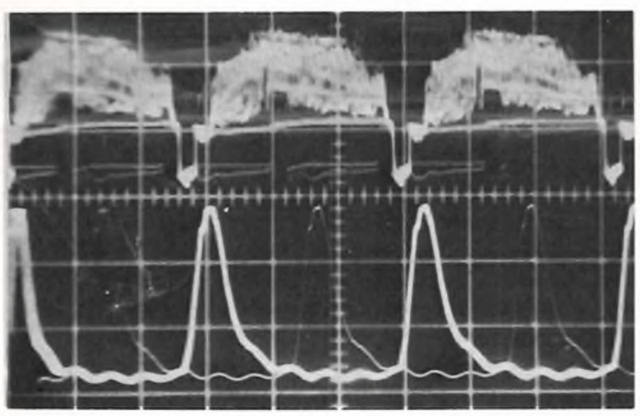
to observe this signal to be sure it is correct. Most triggered scopes do not offer sensitivity this high. If their sensitivity is in the order of 20mv/cm, as most are, you will not be able to check these low signals. We have designed the PS163 to enable the user, whether he be an engineer, designer or technician, to easily and accurately monitor these signals."

With a Sencore scope, you can make any measurement you need in a color or black and white set, even on the vertical and horizontal output stages. You are also assured that your Sencore scope will continue to operate perfectly, even if accidents occur. In our opinion, you will find it difficult to match the specifications and features of either of our scopes; the PS148 service scope or the PS163 lab type triggered scope.

We are taking the time to bring out these different points in comparison fashion so you will be more knowledgeable and be able to make a factual decision on the scope you need.

6 HOW DO YOU MEASURE SIGNAL AMPLITUDE ?

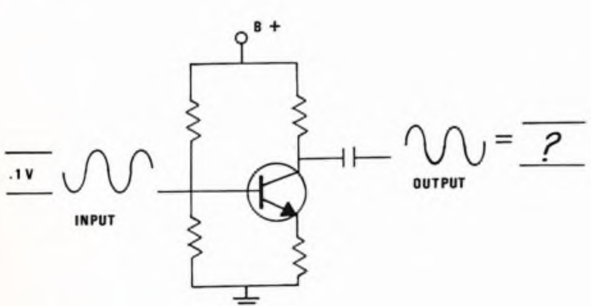
One of the important aspects of waveform analysis is the amplitude or strength of the signal being observed. In almost any circuit, correct operation is dependent on specific signal levels. Even though the shape of the signal may be correct, the circuit will not function properly if the signal is excessively high or low in amplitude. You must be able to observe and measure these signals to quickly and accurately evaluate circuit performance. An example is the chroma burst amplifier or burst gate in a color television receiver. This stage requires the burst pulse, transmitted from the station, and the internal horizontal flyback pulse for correct gating. If the horizontal pulse is



Horizontal and burst pulses are necessary for color reproduction.

to low in amplitude, the stage will not be gated properly or may not be turned on at all, resulting in poor or missing color. It is important then that the scope not only display the waveform clearly but that the amplitude of the signal can be quickly and accurately measured.

Another area that definitely requires AC voltage measurements is the design lab. Any amplifier design must be checked to determine if the gain of the stage corresponds to that required for the application. The most convenient way to accomplish this is with an accurately calibrated, wide band oscilloscope.

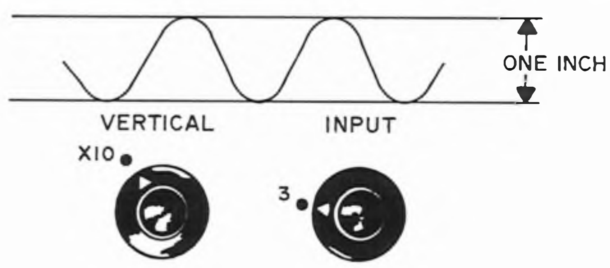


Circuit gain can be checked easily with an accurately calibrated scope.

Many different methods have been used in various scopes to allow measurement of signal amplitude. Some scopes are arranged so you must first calibrate the vertical input. This is done by adjusting the vertical gain control to produce a certain amplitude display on the scope screen. Amplitude measurements can then be made as long as the vertical gain control remains untouched. If the vertical gain control is changed, the calibration procedure must be repeated.

Some scopes also use different grids on the graticule to compensate for changes in amplifier gain at different input settings. This tends to add confusion to the otherwise simple amplitude measurements.

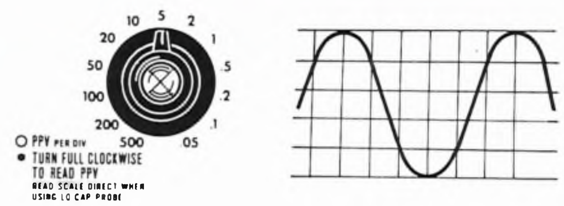
Sencore has designed their scopes to be as simple as possible so amplitude measurements can be made easily. The PS148, for example, uses calibrated input controls for this function. The procedure to follow when making amplitude measurements is to adjust the controls so the display is 1 inch in height or fills between two grid lines. The amplitude is determined by a simple reading of the controls, much the same as the voltage measurements made with a VOM or VTVM. In the example shown here, a one inch display is obtained



with the control settings as pictured. 3 (on) the vernier control) times 10 (setting of the range switch) equals 30 volts. This is the peak-to-peak amplitude of the input signal to the scope. This method of making peak-to-peak voltage measurements by direct reading greatly simplifies these measurements.

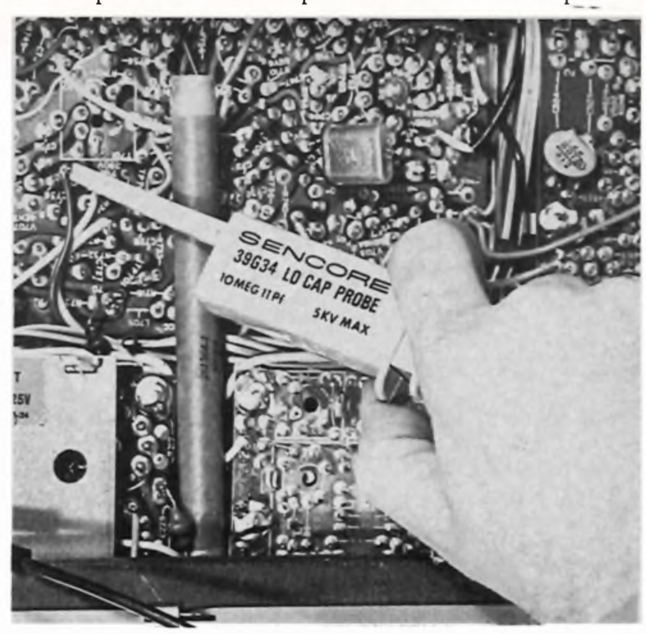
The new PS163 uses a 10 by 10cm grid and calibrated input controls to facilitate waveform measurements. The controls are calibrated in volts per division (centimeter) to correspond to the centimeter divisions on the grid, which are standard on on lab-type scopes. One very convenient feature of the PS163 is the direct calibration of the input controls for use with a low-cap or 10X probe. This simplifies voltage measurements by eliminating the usual calculation necessary when using this standard probe. The measurements are made more rapidly with less chance for error.

The peak-to-peak amplitude of the input signal is found by determining the number of divisions or centimeters of display and multiplying by the setting of the vertical input attenuator. The condition shown here is a 5 division display on the 5 volt per division range. The number of divisions (5) times the number of volts per division (5) gives us an amplitude for the signal of 25 volts peak-to-peak. If the probe being used with the



PS163 is a direct probe, which is seldom used, the result of the calculations above would be multiplied by .1 to obtain the correct amplitude figures.

Circuit connections are made easily too, with the specially designed low capacity probes provided. The long, thin probe with retractable tip makes it a breeze to connect to those hard-to-reach areas found in much of the electronic equipment you encounter. Special grips have also been added to the probe to make operation fast and simple.



Specially designed Hi Voltage, Low Capacity probes make testing easier.

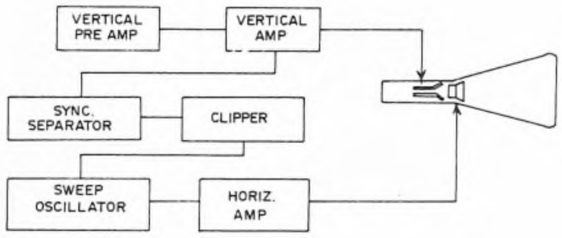
The PS163 also provides both DC and AC coupling of the input signal. AC coupling is normally used for troubleshooting and waveform analysis. The addition of DC coupling allows quick DC measurements to be made with the oscilloscope, eliminating time spent connecting and making the measurement with a meter. Voltage measurements are made by using DC input coupling and observing the vertical shift of the display either above or below a chosen reference line on the scope graticule. The number of divisions the trace shifts times the setting of the input attenuator will supply you the voltage level information necessary for circuit testing.

Both Sencore scopes have been designed to permit easy amplitude measurements of AC signals; and the PS163 provides DC voltage measurements as well. The accuracy of the PS148 is 5%, and the PS163 boasts 2% accuracy. Either way you choose, you have a scope which gives you the accuracy and speed you want.

7 WHAT IS A TRIGGERED SCOPE?

The last year or so has seen the term "triggered scope" advertised and promoted heavily. Many new "triggered" scopes have been added to the market, most of them low-cost import instruments which do not necessarily provide all the features really associated with a quality triggered sweep oscilloscope.

The only real difference between a service type free-running scope and a triggered scope is the manner in which the sweep signal is obtained. The "service type" oscilloscope, such as our PS148, uses a "recurrent sweep" or "sync-sweep" system for generating the necessary sweep signal. This system employs a free-running oscillator capable of covering a wide frequency range which produces the sweep signal, usually a sawtooth. This



Typical circuits for a free running scope.

signal is then amplified and applied to the horizontal deflection plates of the CRT. A sync circuit is employed to "lock" the oscillator to the input frequency providing the stability necessary for observation of the waveform. This system in many ways compares to the vertical sync circuits found in television receivers.

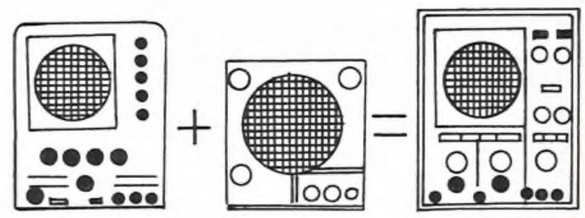
A triggered sweep oscilloscope does not have continuous or recurrent sweep. This system relies on the input signal to provide a pulse which will initiate or "trigger" the sweep. One of the simplest explanations would probably be to compare the sweep circuit to a mono-stable multivibrator. In the absence of a trigger pulse, the sweep is held in the "off" state by the multivibrator. As mentioned previously a sample of the input signal is applied to a high gain amplifier and a squaring amplifier to produce a sharp square wave for the trigger pulse. As soon as the trigger pulse is received, the multivibrator switches states and a capacitor is charged, producing the sweep signal. When the voltage reaches a specific level, corresponding to the point at which the beam reaches the right side of the CRT, the multivibrator switches back to the original "sweep off" state. This rapidly discharges the capacitor which produced the sweep voltage, causing the beam to retrace to the left side of the CRT. Additional circuits are used to hold the sweep off until another trigger pulse is received. The sweep signal produced by this system is linear and can be calibrated in "time per centimer (division)" to allow time and frequency measurements to be made directly.

The Sencore PS163 uses this form of simple, reliable trigger circuitry to produce ultra linear and calibrated sweep signals. A high gain trigger amplifier is used to provide the trigger sensitivity necessary to sync on the low level signals found in today's solid state equipment. In addition, special circuits have been added to the time base to permit operation in three different modes. The PS 163 can be operated in manual triggered, automatic triggered, or free running modes, to offer the greatest versatility for any application.

Free running and triggered operation is a Sencore exclusive.

The automatic triggered mode is probably the one used most often. This mode of operation presets the trigger (sync) level so adjustment of the sync level control is not necessary. The automatic triggering also provides a trace on the CRT at all times, whether input signal is present or not. This assures you that the scope is operating and ready to go. As soon as a signal is applied, the trigger circuit takes over to give you a sharp, clean trace with triggered stability. All you have to do is set the input sensitivity and the sweep speed needed to display the signal. Fast waveform checks with "fiddle free" operation make the automatic trigered mode of the PS163 a real timesaver.

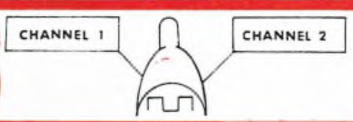
The manual triggered mode is used when you wish to manually set the trigger point on the input signal. The sync level control is fully operational giving you complete control over trigger level and sensitivity. This mode is used when the input signal is extremely low or you want to look specifically at one point on the waveform display. The manual trigger mode allows the trigger point to be selected almost anywhere on the input signal. Both manual and automatic triggered modes offer accurately calibrated time base rates and the solid stability expected of a triggered sweep scope.



PS163 provides function of both triggered and free run oscilloscope

The last mode of operation is a free running mode. This feature converts the PS163 to a free-running sweep like a service type scope, with operation exactly the same as the free running service scope you now use. The free running capability makes it easier for you to operate as well as making the PS163 the most versatile oscilloscope available today. Try it, you'll see what we mean.

8 WHAT IS GAINED BY HAVING DUAL TRACE?



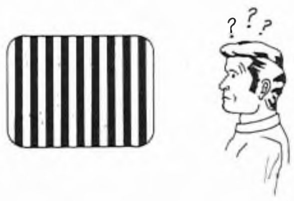
Many, many oscilloscopes have been manufactured and sold with just single trace capability. You undoubtly have either owned or used scopes of this type. They serve a very good purpose, but in many cases fall short of being the "ideal instrument" for your needs. This is particularly true when you are dealing with a triggered scope.

The primary advantage of the triggered scope compared to a free-running service type scope is its capability to begin the sweep at precisely the same point on each trace. This allows extremely accurate comparisons to be made between two signals of the same frequency. Unfortunately, most of the triggered sweep oscilloscopes available today are unable to offer this function as they are only single trace instruments; the most valuable aspect of the triggered sweep scope is missing.

Many of you may feel a single trace instrument is adequate, but let us show you some examples of how a dual trace scope can aid you in your work.

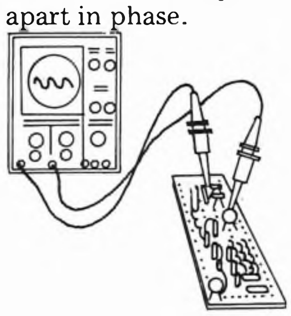
You are working on a stereo amplifier and have restored operation but the balance control must be turned off center to the left channel to get equal output from both channels. A single trace may be enough to observe each waveform, but a comparison between signals on a dual trace scope would speed the troubleshooting.

Or, you are an instructor teaching the subject of multivibrators and have shown the waveforms on both stages but have no means of comparing the phase for the student.



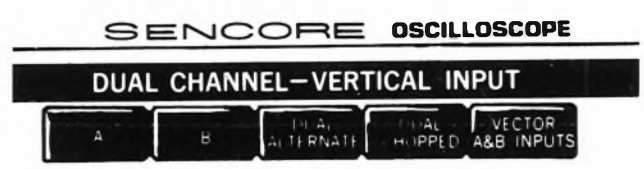
Or, the flesh colors are wrong on a color set and you know both 3.58MHz demodulation signals are present but you are unable to determine if they are 90° apart in phase.

Or, you are an engineer designing an amplifier stage, and have to keep switching the lead between input and output to measure gain, when you could do it without this inconvenience with a dual trace scope.



These are just a few examples where a dual trace scope would be invaluable. You can certainly think of other situations you have encountered when the dual trace capability of the PS163 would have saved time, and made you more confident of your diagnosis.

The PS163 provides dual trace operation in two display modes; dual alternate and dual chopped. The dual alternate display is the mode most commonly used. The operation in dual alternate is simple. The channel A trace is displayed on one cycle of sweep. The next sweep cycle displays channel B input. The third cycle of sweep displays channel A again and so on. Both traces are controlled independently except for the triggering. This is controlled by the trigger source you have selected. One signal will then be displayed in reference to the other. For example, if you have chosen Channel A as the trigger source, you will see the channel B signal displayed in "real time" comparison to channel A. This results because the sweep, regardless of input signals being displayed, is controlled by the signal present at the input to channel A. This is quite valuable when you wish to compare phase between two signals. You not only can see both signals, but with a triggered sweep, you are able to see them displayed on a "real time" basis for accurate comparison of timing or phase relationships. This you cannot do with a triggered scope giving you only single channel display.

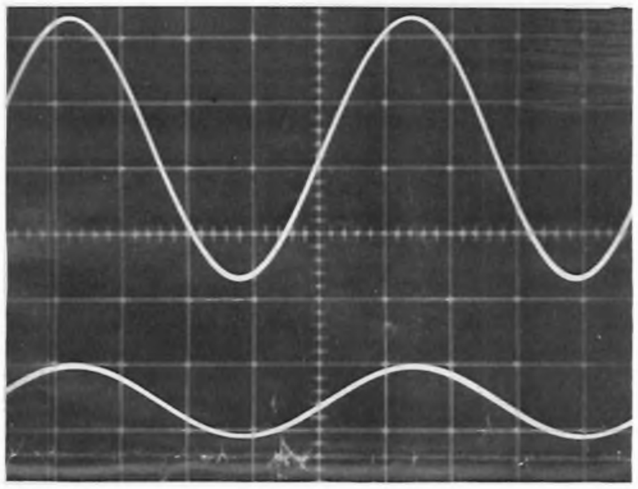


The PS163 also has a dual chopped mode. This is used primarily to obtain dual trace display of low frequency signals, usually those below 60Hz.

At this slow sweep speed in the dual alternate mode, the display will have a tendency to blink because the phosphor does not hold its illumination until the next trace. The dual chopped mode will provide a more steady display by switching between Channel A signal and Channel B signal at a 100 KHz rate. This means channel A signal will be displayed on the positive swing of the 100KHz chopping square wave, and the channel B signal will be displayed on the negative swing. This reduces the amount of time between traces and helps to eliminate the flicker. The chopping frequency is high enough to provide an unbroken display of both signals even though they are displayed in segments.

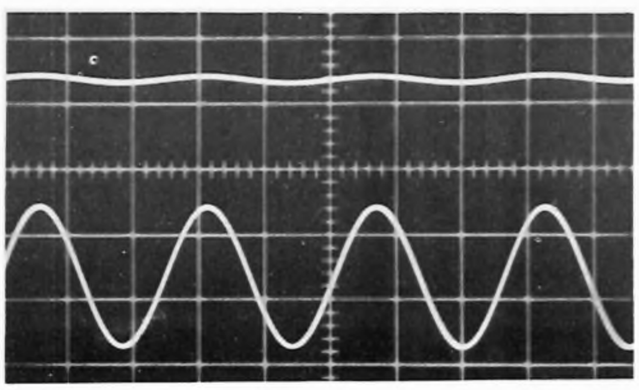
The PS163 is dual channel - dual trace and triggered to make certain you have an oscilloscope that is complete. Waveform comparisons, which can greatly speed troubleshooting and repair, are easily made on this truly professional instrument. Nothing has been left off!

Let's look at some of the areas mentioned before when we wished we had a dual trace scope. The first area mentioned was the audio amplifier with poor balance. A check of the output would immediately confirm the problem as the left channel signal, shown on the lower trace, definitely has a lower amplitude.

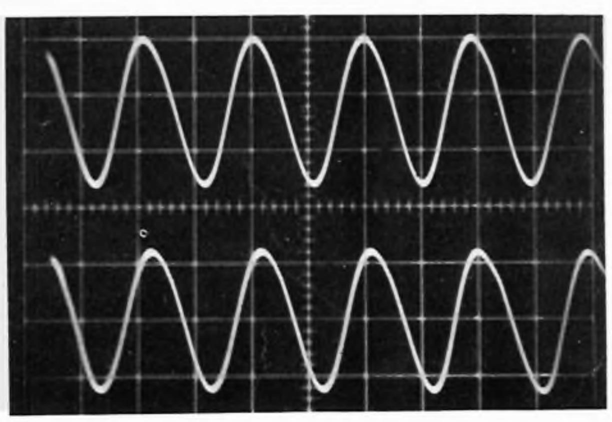


Dual Display makes signal comparison easy.

Checking back through the stereo amplifier, with one channel connected to "A" input and the other to "B" input of the scope, would bring us to the stage which shows even inputs but uneven outputs when the two channels are compared. Looking at the emitter of both stages as shown here, would point out a signal present on left channel (lower trace) but not present on right channel. A quick check would show the emitter bypass capacitor open. Replace the capacitor and we're back in business.

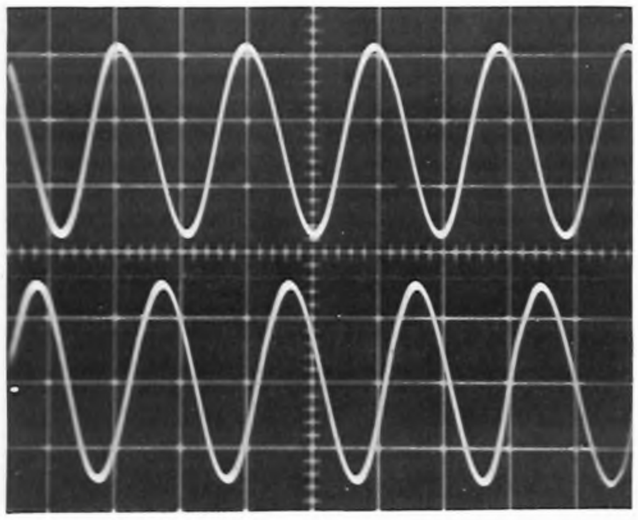


Unequal emitter signals point out the source of the problem.



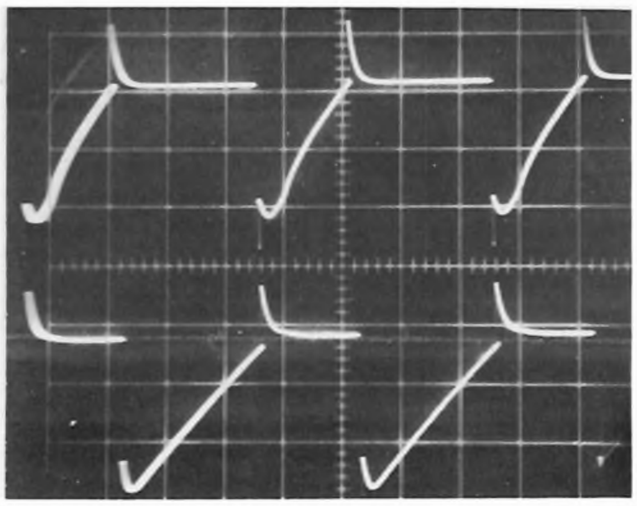
Comparison of color demodulator signals shows incorrect phase angle.

The wrong flesh color on the color receiver is the next problem to face. Connecting the PS163 to both demodulator grids shows the phase of the two 3.58MHz demodulating signals to be much less than 90°, causing the flesh color problem. Solution: leaky capacitor in 3.58MHz phase shift network. Second waveform shows proper phase relationship restored by changing the defective capacitor.



Proper phase angle at demodulator is necessary for good color.

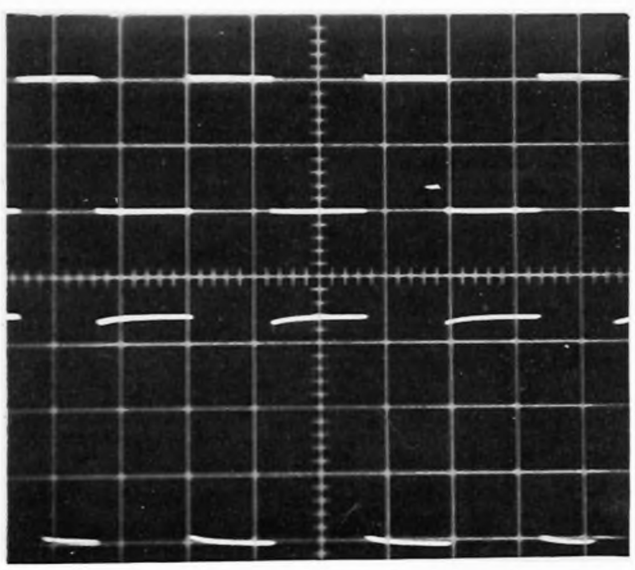
The instructor who wished to display both base signals of the multivibrator would find demonstration much easier with the PS163. The signals shown here are taken from such a multivibrator and clearly show the 180° phase shift present on these signals.



Multivibrator signals are easily displayed on PS163 to aid instruction.

The instructor can also use the PS163 to teach both triggered and free-running scope operation, eliminating the need to purchase two scopes. This makes that meager budget money stretch much further to buy other necessary lab equipment.

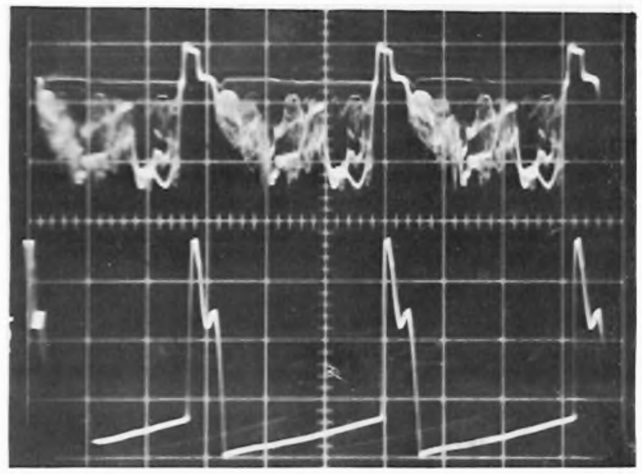
The engineer will find many uses for a versatile scope such as the PS163. The amplifier gain problem mentioned earlier can be checked quickly with the PS163. The upper trace is the input signal displayed on Channel A with a sensitivity of .1 v pp/Div. The lower trace is the output of the amplifier displayed with Channel B sensitivity set at 1 v pp/Div. The gain is determined quickly to be 17. The AC and DC coupling of the PS163 also lets the engineer make quick DC measurements during his testing, eliminating the time consuming task of switching to a VTVM or other meter for this purpose.



Amplifier gain and signal checks are a snap with the dual trace PS163.

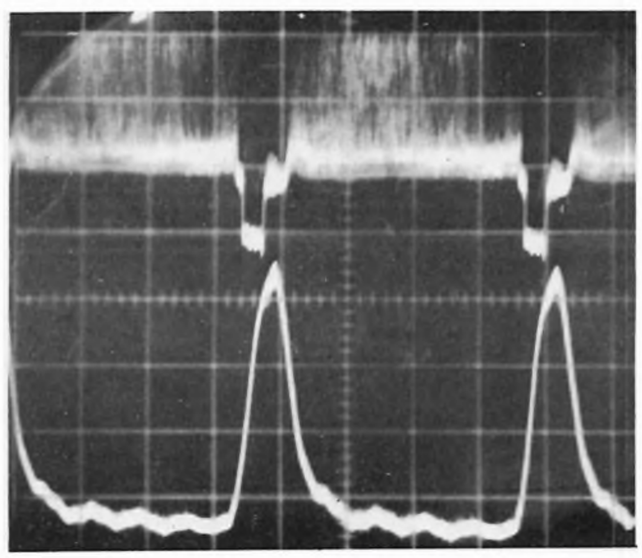
These uses are all important reasons why you can speed your work with a dual-trace scope. There is another area which is probably the most critical and absolutely demands a dual trace-triggered scope. This is the measurement and comparison of concurrent waveforms; those which must occur at exactly the same time or simultaneously.

Concurrent waveforms are present in much of the electronics used today. A television receiver, for example, has concurrent waveforms in several areas. The AGC Keyer must have both the video signal at its grid and the flyback pulse at its plate, with the proper timing, to develop AGC voltage. The photo shown here is typical of the relationship or timing of these signals.



Proper pulse timing is essential for correct AGC operation.

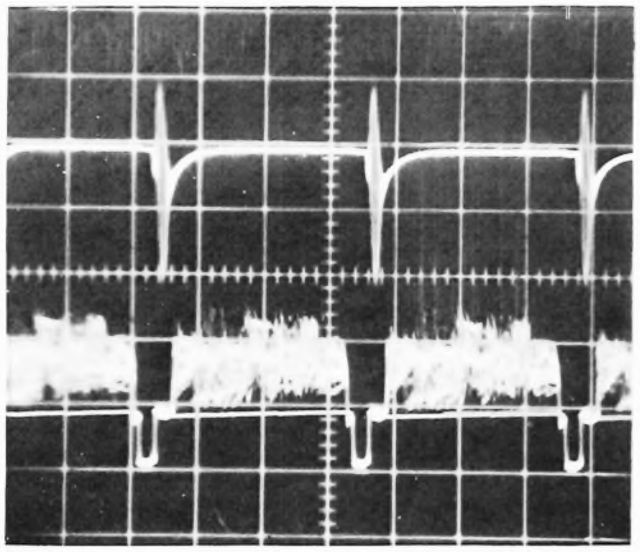
The color section of a color receiver also depends on accurate pulse timing for proper operation. The burst amplifier or burst gate stage separates the transmitted burst signal from the composite video signal and must be turned on at exactly the right time by the flyback pulse. The burst signal is present on the back porch of the horizontal blanking pedestal and has a duration of only .2 microseconds. Obviously, the timing between the flyback and burst pulses is very critical. The dual trace operation and wide time base range of the PS163 makes observation of these pulses easy.



Timing between burst and flyback pulses determines presence of color on screen.

The first photo shows the relationship between the burst signal and the flyback pulse at the burst gate. Note that the flyback pulse is correctly timed with respect to the burst signal.

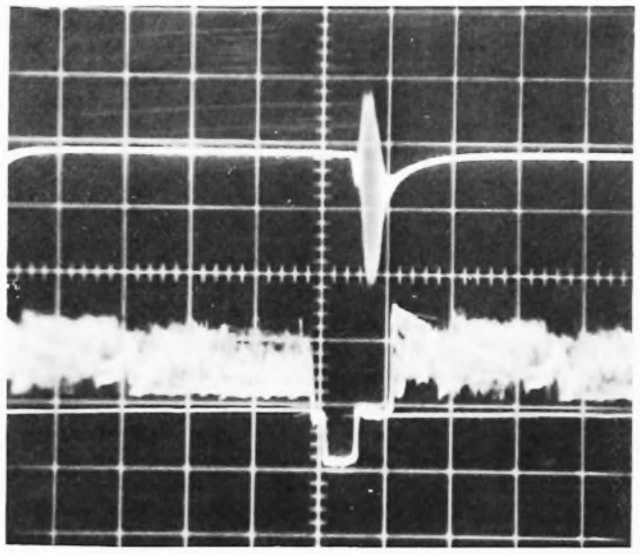
Proper burst gate operation can also be observed by its output signal. This series of photographs compares the output of the burst gate to the composite signal at its input. The first photo shows 3 cycles of each signal, the second just one cycle, and the last photo gives a chance for close signal observation by using the 5X expand feature of the PS163. If the color receiver has poor or no color, it is wise to check the burst gate for proper operation. A scope with only single trace capability will not allow you to make the quick, concise



3 cycles of chroma information and burst output viewed with time base set to 50usec/DIV.

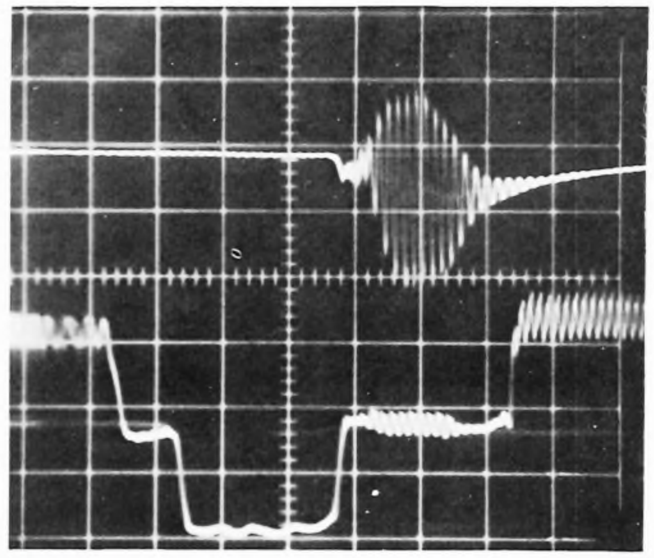
measurements and comparison we have just shown you.

Digital circuitry also contains many concurrent waveforms to provide proper timing and circuit



Time base of 20usec/DIV. lets us view just one cycle of color signal and burst pulse.

function. The use of digital circuitry is rapidly increasing and a dual trace, triggered oscilloscope is a must when checking and servicing these circuits.



5X expand feature on 20usec/DIV. time base gives us expanded look at color burst information.

The PS163 does it all; whether you are engineer, instructor, technician, or student. There is no other low-cost scope that will match the features and versatility of the PS163!

9 WHY DO YOU NEED DUAL CHANNEL FOR DUAL TRACE?

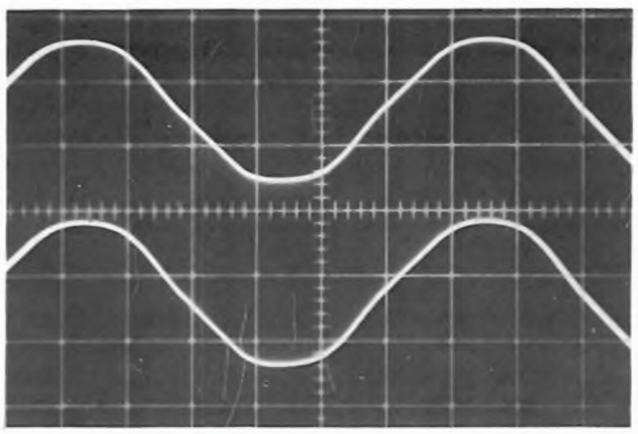
The main purpose of having dual trace capability in an oscilloscope is to be able to accurately display and compare two waveforms. First, to be able to display the waveforms you must have some means of producing two separate displays on the screen. This can be accomplished by different methods.

One of the best methods, and also the most costly, is to use a CRT with a dual beam electron gun. Using this type of tube, you have two beams which gives you easy dual trace capability. This method, as mentioned, is very costly and is used only in extremely high priced lab instruments.

A second method, and the method most commonly used, is to incorporate a high quality single beam CRT and alternate the trace position on the CRT for each sweep. This is accomplished by switching the DC potential applied to the deflection plates. To obtain dual alternate operation, the voltage is changed at the completion of each sweep cycle. The trace position is controlled by the position controls on the front panel of the scope and as the signal applied to the plates is switched from one input to the other, so is the position voltage.

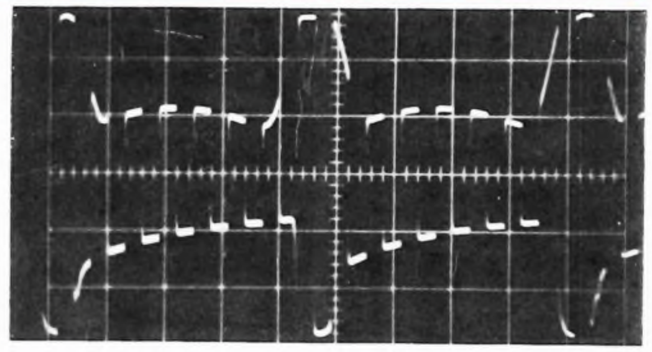
The signal input could be switched before amplification to produce dual trace display with a single vertical amplifier but many problems would result. First, the switching involved to do this becomes extremely complex. Second, you would not be able to adjust the gain of the amplifier to compensate for differences in input signal level. For example, if one input was 50vpp and the other was 2vpp, you would be able to adjust for convenient display of the 50 volt signal. The 2v signal would be handled by the same amplifier with the same gain setting. As a result, the 2 volt signal would be so low in amplitude that it would not even provide a display. This system would not be acceptable for most applications. A dual amplifier arrangement is needed to give independent control on the amplification of the input signals.

Another method which is advocated by some test equipment manufacturers is the use of an external electronic switch. The function of the electronic switch is to provide a dual trace display on a single trace scope. This is accomplished by using a square wave signal, developed in the electronic switch to connect the input signals to the scope. One of the input signals is displayed during positive swing of the square wave. The other input signal is connected to the vertical amplifier by the negative portion of the square wave. This is equivalent to the dual chopped mode of the PS163. The chopping or switching signal is usually 50KHz or lower on the electronic switches. Examples of dual trace display with this type of dual trace system are shown here.



Low frequency signals can be seen quite well with electronic switching system.

The signals are two identical 60Hz sine waves displayed by means of a 50KHz switching signal: the display looks quite good, and this is true on the lower frequencies. The shortcoming of the system is its inability to display any meaningful signal at a frequency above 1/10 the frequency of the chopping signal. Let's show you what we mean.



Horizontal & AGC signals are completely distorted and meaningless when chopped.

Here we have the signal at the horizontal output grid applied as one input, and the AGC keying pulse is used as the other input. The frequency of both signals is 15,750Hz and the chopping or switching square wave is 100KHz, twice that of the highest frequency used in electronic switches. The display is completely distorted and useless. What would it look like at 3.58MHz color frequencies?

This system also has many other disadvantages. The bandpass is very low, usually 300KHz or less. There is no calibration on the input signals so you are unable to measure signal amplitude. It is our opinion that this is certainly not the way to obtain dual trace display. The only practical way to get accurate, calibrated dual trace display is to use dual amplifiers to provide full dual channel input. In this way you have complete control over signal amplitude, coupling, trace position and display mode. The dual alternate display mode of the PS163 provides sharp, clear displays with full sensitivity, even on the fastest sweep speeds. The dual channel input with distortion free amplification assures accurate displays. For the lower frequencies, when the slower sweep speed would tend to make the trace "blink", the dual chopped mode comes into play. Just push the button and you have the electronic switching to provide the steady display you need for analyzing these signals. The dual channel dual trace PS163 has been designed to fill all your needs whether you are designing, servicing or teaching electronics.

10 DO YOU NEED THE VECTOR OR X-Y MODE?

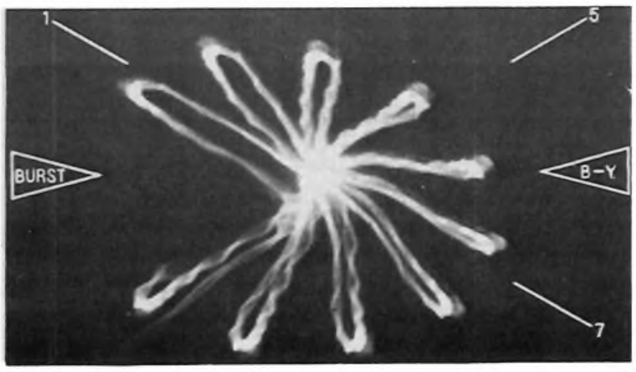
Let's look at a few situations that are encountered every day to determine if a Vectorscope or X-Y scope has practical application. You are a television service technician and are working on a color receiver. The complaint is poor flesh color and incorrect colors. Now what possibilities are involved? Bad tubes? Poor alignment? CRT? 3.58MHz Oscillator? Phase Circuit, maybe? Sure, there are many possible sources for the trouble. How to find out where - fast? Stick with us and we'll see.

The electronics instructor is trying to explain the phase relationships between voltage and current in a circuit containing a capacitor or inductor. Now this isn't always easy to do because it can sometimes be a bit difficult to prove. If he just had some way of displaying the voltage phase vertically and current phase horizontally on a scope, (without loading the circuit or introducing tremendous phase shift in the scope) the job would be much easier.

Or the engineer is working on a critical power supply and wants to know the load line of the supply. Determining this by conventional methods gets to be a real chore.

What's the simple answer to all these problems? The Sencore PS163 of course. The full sensitivity vectorscope included in the PS163 provides the fast, simple answer needed for these and many other problems, and operation couldn't be easier. The connections are right on the front panel with the same probes used for other measurements. Just push the Vector display button and you're all set to go with 5 millivolt sensitivity. The results are accurate, too, as the matched vertical and horizontal amplifiers have less than 3° phase shift all the way up to 5MHz. The vector grid is provided right on the scope, so you don't have to spend valuable time changing grids. Just slide the scale illumination switch to Vector and you're all set. Shall we look at our problems?

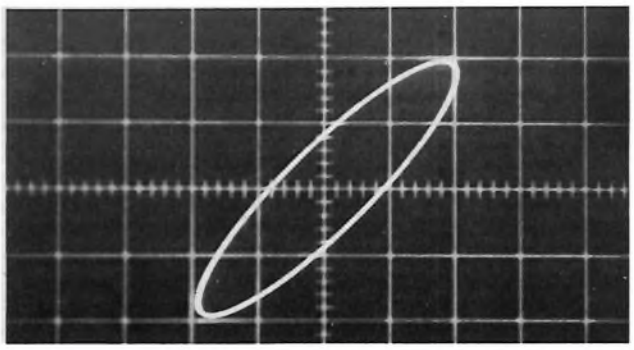
The color set with the annoying and sometimes elusive color problem is very simple when the PS163 Vectorscope comes to your rescue. Just connect the R-Y and B-Y outputs and push the button. The petal pattern pops on the screen.



Typical Vector pattern on PS163.

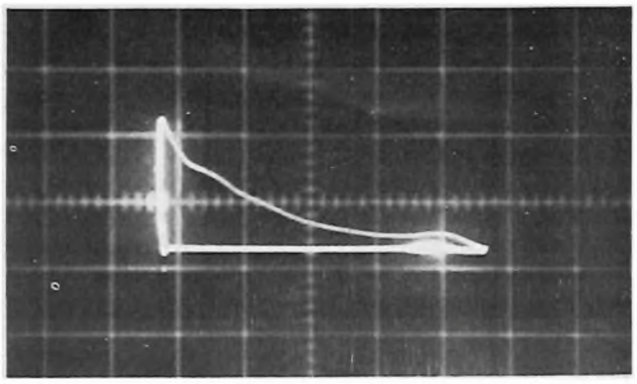
You can use the Vectorscope to check alignment of the chroma circuits and AFPC circuits as well, to touch up the set for best performance. If you're working on a real toughie, you can even look at the pattern at the demodulator output on the new IC demodulators. One big advantage of the 5mv sensitivity.

Now for the instructor. All he needs to do to show his students the phase relationships, is place a resistor (small value as the PS163 is sensitive) in series with the capacitor or inductor and hook up. Compare the voltage across the reactive component and the drop across the resistor in the Vector mode and we have a Lissajous pattern. A quick calculation gives us the phase angle. Hard points like this are easy to explain when the school has equipped its labs with the Sencore PS163.



Lissajous patterns for frequency and phase measurements are a must for schools.

The engineer working on the power supply has his job just as simple. Placing a one ohm resistor in series with the output of the regulator transistor allows him to "see" the current characteristics of the supply. One connection across the resistor and the other across the output to monitor voltage, press the Vector button, and instant load line.



Power supply, tube & transistor load lines are a breeze with X-Y mode of PS163.

This PS163 is a real problem solver. Whether it's the color petal pattern, Lissajous phase or frequency comparison, or load lines on power supplies, tubes or transistors, the PS163 is ready at the push of a button. With virtually no phase shift and unmatched sensitivity, it's unbeatable.

We have attempted to point out some of the many reasons, or needs, for the PS163 Dual Trace Triggered Sweep Oscilloscope and some of the many things it can do for you. You may already be heading for your nearest distributor to pick yours up, but if you are still hesitating, we have included a full list of specifications. A comparison chart is provided, too, to help you choose the right scope for you. Of course, we both know it is the PS163. See you next month!

SPECIFICATIONS

VERTICAL AMPLIFIER (For Both Channels A and B)

Sensitivity	.005V/cm to 50V/cm in 13 overlapping ranges. Front panel calibrated from .05V/cm to 500V/cm for direct reading with low cap probe. . . . Continuously variable gain between steps. 2% calibration accuracy.
Bandwidth	DC to 8MHz-3DB. Useable to 15MHz.
Overshoot	Negligible -- 1% or less
Rise time	40 nanoseconds
Input impedance	1 meg shunted by 35pf at input terminals. 10 meg shunted by 11pf using low cap probe.

HORIZONTAL SWEEP

Time base (Manual and Automatic)	.1 microseconds/cm to .1 second/cm in 19 calibrated ranges continuously variable between steps. 2% calibration accuracy.
Free Running	1 Hz to 1MHz in 19 ranges, continuously variable between steps. Calibrated in frequency.
Sweep Magnifier	5 times
Horizontal input	Variable, uncalibrated
Input impedance	1 meg shunted by 40pf

SYNCHRONIZATION

Manual triggering	Choice of Channel A, Channel B, Line or External, positive or negative polarity, level variable.
Automatic triggering and free run	Choice of Channel A, Channel B, Line or External, positive or negative polarity.
Trigger level requirements	Internal Channel A, B, or Line -- 1 cm of display. External -- 50mv minimum; input Impedance -- 1 meg shunted by 40pf.

VECTORSCOPE OPERATION: (Channel A vertical--Channel B horizontal)

Sensitivity	.005V/cm to 50V/cm direct, .05V/cm to 500V/cm using low cap probe.
Frequency response	DC to 8MHz vertical, DC to 7MHz horizontal.

GENERAL

Calibrate signal to check vert. amp. calibration accuracy	1KHz, 2vpp square wave through front binding post.
Graticule	2 layer illuminated with switch selection of either 10 x 10cm grid or vector grid.
Power requirements	105 to 130 VAC, 60Hz, 60 watts
Size	12 x 10 x 15½
Weight	30 lbs.

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We have been receiving many letters requesting subscriptions to the Sencore News. The Sencore News is sent free to any person who has purchased Sencore equipment and sent in a warranty card to register their purchase. If you wish to receive the Sencore News, just send us a warranty card from any Sencore instrument you purchase and your name will be added to our mailing list. The only exception to this policy is for Vocation Electronics instructors who wish to receive this information. They will be added to the mailing list simply by sending us their name, address, school and area of instruction.

TRIGGERED OSCILLOSCOPE COMPARISON CHART †

	Sencore PS163	Brand A	Brand B	Brand C	Brand D	Brand E	Brand F
Country of Origin	USA	USA	England	England	Japan	Japan	Canada
Dual Trace	YES	YES	NO	YES	NO	NO	YES
Triggered and Free Run	YES	NO	NO	NO	NO	NO	NO
Vector or X-Y Mode	YES	NO	NO	NO	NO	NO	YES
Maximum Sensitivity	5mV	50mV	10mV	10mV	10mV	20mV	50mV
Maximum Input Voltage (with Low Cap probe)	5kV	600V	600V	600V	600V	600V	600V
Minimum Sweep Speed	1Hz	.1Hz	.1Hz	.2Hz	.2Hz	.5Hz	1Hz
Maximum Sweep Speed	1MHz	500KHz	500KHz	500KHz	200KHz	100KHz	500KHz
TVV and TVH with Sync Separator	YES	NO	YES	YES	YES	NO	NO
Line Sweep with Adjustable Phase	YES	NO	NO	NO	NO	NO	NO
Overshoot	NONE	NONE	2%	2%	3%	N.A.*	Less than 10%
Selectable Internal Trigger Source	YES	NO	NO	YES	NO	NO	YES
External Sweep	YES	YES	YES	YES	YES	YES	YES
Illuminated 10 x 10 and Vector Grids	YES	NO	NO	NO	NO	NO	NO
Regulated Power Supply	YES	YES	NO	N.A.*	N.A.*	N.A.*	YES
Regulated High Voltage	YES	YES	NO	N.A.*	N.A.*	N.A.*	YES
Construction	SOLID STATE	TUBE	HYBRID	HYBRID	SOLID STATE	HYBRID	SOLID STATE
Price	$595 w/probes	$1500 +probes	$350 +probe	$1075 +probes	$390 w/probe	$340 +probe	$565 +probes

† Information compiled from manufacturers specification sheets and believed to be correct at time of printing.

* Information not available.

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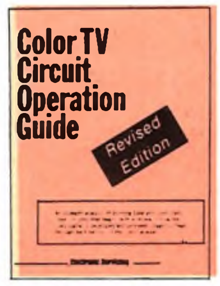

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