



## A Dual-Trace Automatic Base Line Oscilloscope For The DC - Several Hundred KC Range

**D**UAL-TRACE oscilloscopes, since they permit two separate waveforms to be viewed simultaneously, considerably simplify work in circuits and systems where changes in waveform are involved or where time or phase relationships are of interest. Fig. 2 shows a representative case where the dual-trace display is of value.

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To make available the convenience of the dual-trace feature in an instrument for the dc to several hundred kc range, the new oscilloscope shown in Fig. 1 has been designed. A special feature of this instrument is that the dual-trace display is supplemented by an automatic base-line provision such that, when no signal is applied, a low-rate sweep automatically occurs. Two horizontal traces are thus presented to make the positions of the base lines for both vertical amplifiers always known. In

establishing set-ups and making initial adjustments, this feature is of considerable convenience. When a signal to be viewed is then applied, the sweep will automatically trigger from the signal in most modes of operation.

In its other characteristics the instrument is designed to be suited to many applications in its frequency range. The two vertical amplifiers are identical with 3 db points above 200 kc and maximum sensitivities of 0.01 volt/cm. Several different vertical presentations can be selected, as described more fully later. An internal square-wave calibrator enables the vertical system calibration to be easily checked when desired. Calibrated sweep speeds extend down to 5 microseconds/cm which can be increased to 1 microsecond/cm with a x5 sweep expander. The horizontal amplifier has a maximum sensitivity of 0.1 volt/cm and is identical in bandwidth to the vertical amplifiers with less than

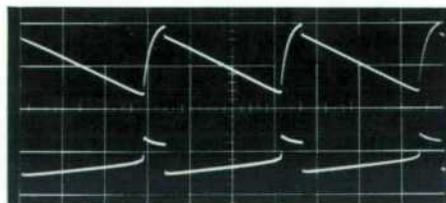


Fig. 2. Oscillogram indicating typical instance where dual-trace oscilloscope permits two-phenomena comparison, here used to check plate and cathode waveforms of phantastron.

Fig. 1 (left). New -hp- Model 122A Dual-Trace Oscilloscope permits two phenomena within dc to several hundred kc range to be compared simultaneously. Instrument incorporates no-signal sweep such that base lines are automatically displayed in absence of signal to facilitate set-up adjustments.

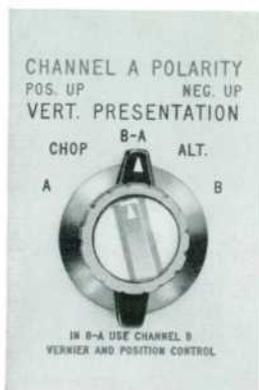


Fig. 3. Vertical presentation selector provides for five types of vertical display. Concentric switch inverts A channel signal to facilitate two-signal comparison.

$\pm 2^\circ$  differential phase shift at 100 kc. If desired, differential phase shift at a higher frequency can be minimized with an internal adjustment.

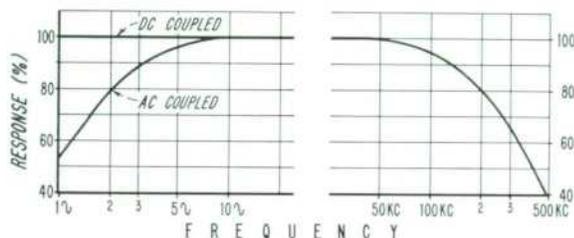
#### VERTICAL PRESENTATIONS

The oscilloscope is designed with a five-position vertical presentation selector (Fig. 3) to permit an optimum display to be selected for a given application. The extreme selector positions (A and B) provide for single-channel presentations, while the intermediate positions present combinations of the two vertical channels, with CHOP and ALT being the dual-trace displays in which the two inputs can be viewed simultaneously. In the CHOP position, the vertical deflection system is electronically switched between the two vertical amplifiers at a 40 kc rate for such purposes as permitting a comparison of single transients and generally facilitating comparison of lower frequency signals. If desired, however, chopped operation can be used to view higher-frequency signals as well, although in the rather remote event that the signal is harmonically-related at a low ratio to the 40 kc chopping frequency, the detail of the presentation will be diminished, since the chopping frequency will be "stopped." Alternate sweeping can then be used. For chopped operation an external trigger is required to prevent the trigger system from synchronizing on the chopping waveform.

#### NONHARMONICALLY-RELATED WAVEFORMS

In the ALT position the sweep alternately presents the outputs of the two vertical amplifiers. This mode is a general-purpose mode for dual-trace presentations at sweep speeds faster than about 10 milliseconds/cm with a P1 phosphor tube. Besides its general-pur-

Fig. 4. Typical bandwidth characteristic of Model 122A. Curve applies to all three amplifiers. Differential phase shift between amplifiers is less than  $\pm 2^\circ$  at 100 kc.



pose nature, however, this position has the special advantage, which is a basic advantage for the dual-trace type of two-channel instrument, that it permits nonharmonically-related signals to be viewed. This occurs because the trigger system can alternately trigger from the two amplifier outputs. The feature is thus useful for such purposes as comparing time markers with non-integrally-related waves where only alternate triggering will "stop" both waveforms. Where the relative phases of harmonically-related waveforms are of interest, however, an external trigger should be used with alternate operation.

Dual-trace displays are additionally facilitated by an inverting switch which is concentric with the vertical presentation selector. This switch changes the polarity of the "A" channel presentation to accommodate phase reversals between different pick-off points in the source.



Fig. 5. Rack-mounting version has been designed with panel height of 7 inches for economy of rack space.

#### DIFFERENTIAL PRESENTATION

The B - A position presents the instantaneous difference between the signal voltages applied to the A and B terminals and is thus specifically suited to viewing signals in differential or balanced sources. The position is also convenient for mixing two harmonically-related signals of widely different amplitudes. Common mode voltages on the differential signal are suppressed by at least 30 db in the B - A position.

Differential inputs are also provided on the most sensitive position of each vertical amplifier. Common mode voltages on the applied signal will be suppressed in the most sensitive position by at least 40 db.

#### VERTICAL AND HORIZONTAL RESPONSES

The two vertical amplifiers are designed to be identical and all three amplifiers in the instrument are designed to have the same bandwidth (Fig. 4) and phase characteristics. Although the high-frequency 3 db point for the amplifiers is rated at 200 kc, it is usually about 40% above this. At the same time roll-off is slow so that the oscilloscope is usable at frequencies considerably above the 3 db point. The trigger system will usually respond to frequencies well above 500 kc to permit viewing of higher frequency signals.

The differential phase shift between the three amplifiers is less than  $2^\circ$  at 100 kc. The A vertical amplifier and the horizontal amplifier include a phase-adjusting capacitor so that relative phase shift can be minimized at a higher frequency if desired.

#### TRIGGER SYSTEM

As mentioned earlier, the trigger system is designed so that in the absence of a signal a low repetition rate sweep occurs to enable the operator to know the position of the base line. If the instrument is set for dual-trace operation, a base line is shown for each amplifier. When a signal is applied, the sweep will automatically trigger from the signal for all but chopped presentations, which require the use of an external trigger signal. If desired, the point on the signal at which the sweep triggers can be selected over a range from  $-10$  to  $+10$  volts with the *Trigger Level* control. This control can also be used to disable the automatic base line sweep when desired.

For cases where it is desired to examine a portion of a display in more detail, the sweep can be expanded 5 times with a switch on the panel. The operation is such that the center 2 cm of the screen is expanded to full screen width, while any 2 cm portion of the unexpanded sweep can be selected for expansion with the horizontal positioning control.

The sweep expansion feature can also be used to increase the fastest sweep of

(Concluded on p. 4)

## TWO HIGH-PERFORMANCE ATTENUATORS FOR THE DC - 500 MC RANGE

ATTENUATORS for use in the region between the ultrasonic range and waveguide frequencies have, in general, had one or more of several disadvantages such as being non-adjustable, having only a limited attenuation range, being non-direct reading, or, in the case of the cutoff type, having a high insertion loss. To overcome these disadvantages, two new 50-ohm variable attenuators have been designed to provide a total of 132 db of



Fig. 1. As a pair, new -hp- Models 355A/B 50-ohm Attenuators provide from 0 to 132 db of attenuation in 1 db steps over dc to 500 mc frequency range.

attenuation in 1 db steps over the frequency range from dc to 500 megacycles. One attenuator provides from 0 to 120 db in 10 db steps, while the second provides from 0 to 12 db in 1 db steps. Each attenuator has been designed with a single direct-reading control both to achieve simplicity of use for typical bench work as well as to permit the attenuators to be incorporated easily into panel or console installations. For such installations it is feasible to mount the attenuators in electrically convenient locations within an equipment bay and either to provide rigid or flexible shafts to operate them from the panel (Fig. 2) or to remotely operate them with suitable stepping mechanisms. The units are also designed with a small cross section so that, in permanent installation applications, they can easily be mounted directly behind a panel as well.

### CONSTRUCTION TECHNIQUE

The basic approach in the design of the attenuators has been to extend the response of conventional lumped-element configurations to a high frequency by closely controlling stray parameters. Both attenuators consist of

a series of pi pads which are connected in cascade to permit a matched 50-ohm input and output impedance to be achieved at all attenuation levels. In high-frequency attenuators of this type it is necessary to locate the pad switches physically very close to the individual pads, but in order to avoid the need for manually operating a multiplicity of switches and to achieve the remote control feature described above a design has been evolved that operates the individual switches from a single shaft. This shaft mounts four cams which operate small sensitive-type switches. These in turn connect the appropriate pads in or out of the network as the control knob is rotated. Since the attenuator is designed as a cascade rather than a ladder type, any combination of pads can be switched in this manner without altering the 50-ohm input or output impedance.

Each attenuator consists of four pads. In the 120 db unit these have values of 10, 20, 30 and 60 db. In the 12 db unit the values are 1, 2, 3 and 6 db. The pads are constructed with precision carbon film resistors for a frequency response well beyond 500 mc. Such a range is possible when care is taken with lead inductances and where capacities are closely controlled.

In the design stage each of the pads was considered separately and its performance optimized as an individual network. By mounting the resistors and switches on a suitable aluminum block, it was possible to control resistor lead length and capacity to ground as well as to achieve repeatability of these factors in production units. The impedance of the individual sections was then checked and adjusted to 500 mc with the -hp- Model 803A VHF Impedance Bridge<sup>1</sup>. In the 120 db unit the result of

<sup>1</sup>Arthur Fong, "Direct Measurement of Impedance in the 50-500 MC Range," Hewlett-Packard Journal, Volume 1, No. 8, April, 1950.

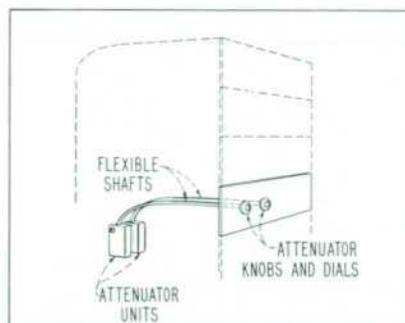


Fig. 2. Single-shaft operation permits attenuators to be mounted in suitable location within racks and operated from panel with flexible shafts or stepping mechanisms.

these measures was that the response of the 10 db pad was down 1 db at 1700 mc, the 20 db pad at 1100 mc, and the 30 db pad at 700 mc. Two of the 30 db pads were then cascaded to form the 60 db pad. In the 0 to 12 db unit the responses were comparable or wider because of the smaller resistance values.

Isolation between each pad input and

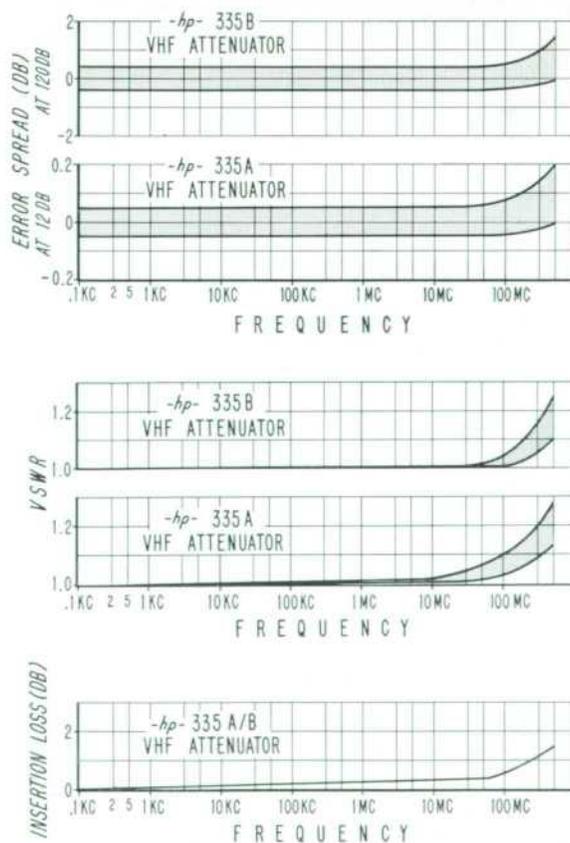


Fig. 3. Typical accuracy, vswr and insertion loss characteristics of -hp- 355A/B.

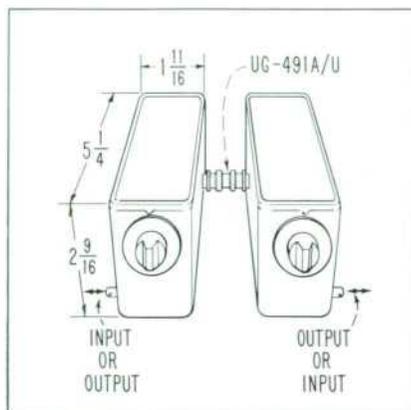


Fig. 4. Overall dimensions of -hp- 355A/B. Adapter noted can be used for interconnection. Solid-shielded cable assemblies are also available.

output is achieved by symmetrically disposing each pad into two compartments of a cast aluminum box. Connections between pads are constructed as 50-ohm lines. A number of designs were tried for these lines, but the simplest and most controllable was found to be a straight bare wire placed next to a movable ground plane and insulated therefrom by an insulating tape film. The arrangement is such that the sepa-

ration of wire and ground plane can be adjusted after assembly to refine the line impedance to the required degree. The operation of the integrated unit was then checked against a standard cutoff type attenuator.

These measures have resulted in the performance indicated in Fig. 3 which represent the tolerances established for production units. The characteristics are not controlled above 500 mc, but the units are ordinarily useful to much higher frequencies for simple level-setting and similar usage where step accuracy is not a factor. Transient response has also been checked with pulses of a few millimicroseconds' rise time without discernible waveshape change.

#### SPECIAL MOUNTING CONSIDERATIONS

To facilitate side-by-side mounting of the attenuators, the terminals are physically located in complementary positions, as shown in Fig. 4. Any series arrangement can be used for connecting the terminals and any terminal can be used for input or output, but the arrangement indicated in Fig. 4 is convenient in that it permits a type UG-491A/U adapter to interconnect the at-

tenuators. For input and output cables, the wide range of attenuation of the units makes it necessary to use double-shielded cable such as RG-55/U. Special solid-shielded cable assemblies are also available to provide a still higher measure of shielding.

—Arthur Fong and Harley L. Halverson

#### SPECIFICATIONS -hp- MODELS 355A/B ATTENUATORS

ATTENUATION: -hp- 355A, 12 db in 1 db steps; -hp- 355B, 120 db in 10 db steps.  
FREQUENCY RANGE: Dc to 500 mc.  
OVERALL ACCURACY: -hp- 355A,  $\pm 0.25$  db, dc to 500 mc; -hp- 355B,  $\pm 1$  db, dc to 250 mc,  $\pm 2$  db, 250 to 500 mc.  
NOMINAL IMPEDANCE: 50 ohms.  
MAXIMUM SWR: 1.2 to 250 mc, 1.5 to 500 mc.  
MAXIMUM INSERTION LOSS: 0 at dc, 0.4 db at 60 mc, 1 db at 250 mc, 1.5 db at 500 mc.  
POWER DISSIPATION: 0.5 watt average; 350 volts peak.  
CONNECTORS: Female type BNC.  
WEIGHT: 1 1/2 lbs. net; shipping weight 3 lbs.  
PRICE: -hp- Model 355A Attenuator, \$125.00. -hp- Model 355B Attenuator, \$125.00.  
ACCESSORIES AVAILABLE: 803A-16E solid shield 50-ohm Cable Assembly, 15 inches long with male BNC connectors, \$9.00. 803A-16D RG-55/U Cable Assembly, 2 feet long, terminated by a male type N connector on one end and a male BNC connector on the other. \$8.50.  
Prices f.o.b. Palo Alto, California  
Data subject to change without notice

#### DUAL-TRACE SCOPE

(Continued from p. 2)

the instrument from 5  $\mu$ sec/cm to 1  $\mu$ sec/cm.

#### GENERAL

To insure stability, the low-level vertical amplifier stages are operated with

some 150 volts of common mode degeneration and with regulated tube heaters. Transistors are used as the control elements in the heater regulator. The main rectifier circuit for the instrument uses silicon rectifiers for long life and low heat dissipation.

A rack-mounting version of the instrument (Fig. 5) has been designed with minimal panel height (7 inches) to conserve rack panel area.

Other characteristics of the instrument are given in the accompanying specifications. —John Strathman

#### SPECIFICATIONS -hp- MODEL 122A DUAL TRACE OSCILLOSCOPE

##### SWEEP

Sweep Range: 15 Calibrated sweeps, accurate to within  $\pm 5\%$ , in a 1, 2, 5, 10, . . . sequence, 5  $\mu$ sec/cm to 200 millisecc/cm. Vernier permits continuous adjustment of sweep time between calibrated steps and extends the 200 millisecc/cm step to at least 0.5 sec/cm.

Sweep Expand: X5 sweep expansion may be used on all ranges and expands fastest sweep to 1  $\mu$ sec/cm. Expansion is about the center of the CRT and expanded sweep accuracy is  $\pm 10\%$ .

Synchronization: Internally from vertical deflection signals causing 1/2 cm or more vertical deflection, from line voltage, and from external signals 2.5 volts peak-to-peak or greater.

Trigger Point: Automatic. Control overrides automatic and permits the trigger point to be set between -10 and +10 volts. Turning fully counter-clockwise into AUTO restores automatic operation.

##### VERTICAL AMPLIFIERS

Bandwidth: Dc coupled: dc to 200 kc.

Ac coupled: 2 cps to 200 kc.

Bandwidth is independent of calibrated sensitivity setting.

Sensitivity: 10 millivolts/cm to 100 volts/cm. 4 calibrated steps accurate within  $\pm 5\%$ , 10 mv/cm, 100 mv/cm, 1 v/cm and 10 v/cm. Vernier permits continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.

Internal Calibrator: Calibrating signal automatically connected to vertical amplifier for standardizing of gain, accuracy  $\pm 2\%$ .

Input Impedance: 1 megohm, less than 70  $\mu$ mf shunt capacitance.

Phase Shift: Vertical and horizontal amplifiers have same phase characteristics within  $\pm 2^\circ$  to 100 kc when verniers are fully cw.

Balanced Input: On 10 mv/cm range on both amplifiers. Input impedance, 2 megohms shunted by less than 35  $\mu$ mf. Common mode rejection is at least 40 db. Common mode signal must not exceed  $\pm 3$  volts peak.

Difference Input: Both input signals may be switched to one channel to give differential input on all vertical sensitivity ranges. The sensitivity switches may be set separately to allow mixing signals of different levels. Common mode rejection is at least 40 db with both switches on most sensitive range, 30 db on other ranges.

##### HORIZONTAL AMPLIFIER

Bandwidth: Dc coupled: dc to 200 kc.

Ac coupled: 2 cps to 200 kc.

Bandwidth is independent of calibrated sensitivity setting.

Sensitivity: 0.1 volt/cm to 100 volts/cm. 3 calibrated steps, accurate within  $\pm 5\%$ , .1 v/cm, 1 v/cm, and 10 v/cm. Vernier permits continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.

Input Impedance: 1 megohm, nominal, shunted by less than 120  $\mu$ mf.

Prices f.o.b. Palo Alto, California  
Data subject to change without notice

##### GENERAL

Cathode Ray Tube: 5AQPI mono-accelerator normally supplied; 2500 volt accelerating potential, P7 and P11 phosphors are also available. P2 is available if desired for special applications.

CRT Bezel: Light proof bezel provides firm mount for oscilloscope camera and is removed easily for quick change of filter.

CRT Plates: Direct connection to deflection plates via terminals on rear. Sensitivity approximately 20 v/cm.

Intensity Modulated: Terminals on rear. +20 v to blank trace of normal intensity.

Filter Supplied: Color of filter compatible with CRT phosphor supplied.

Illuminated Graticule: Edge lighted with controlled illumination, 10 cm x 10 cm, marked in cm squares. Major horizontal and vertical axes have 2 mm subdivisions.

Dimensions: Cabinet Mount: 9 3/4" wide, 15" high, 21 1/4" deep.

Rack Mount: 19" wide, 7" high, 21 1/4" deep. 19 1/2" deep behind panel.

Weight: Cabinet Mount: Net 35 lbs., shipping 51 lbs.

Rack Mount: Net 33 lbs., shipping 48 lbs.

Power: 115/230 volts  $\pm 10\%$ , 50-1000 cps; approximately 150 watts.

Accessories Available: AC-83A Viewing Hood, face-fitting molded rubber, Price: \$4.50.

Price: Model 122A Cabinet Mount: \$625.00. Model 122AR Rack Mount: \$625.00.

Normally supplied with P1 phosphor. When ordering P2\*, P7 or P11, specify by adding phosphor number after model.

\*P2 is not recommended for general purpose usage.