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

DUAL-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.

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.

±2° 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-purpose 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. 4. Typical bandwidth characteristic of Model 122A. Curve applies to all three amplifiers. Differential phase shift between amplifiers is less than ±2° at 100 kc.

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° 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 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 attenuation in 1 db steps over the frequency range from dc to 500 megacycles.

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.

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 capacitances 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 Bridge1. In the 120 db unit the result of 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

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disposing each pad into two compartments between pads are constructed as
ments of a cast aluminum box. Connec-
tions. Solid-shielded cable assemblies
are also available.
output is achieved by symmetrically
posing 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-set-
ting and similar usage where step ac-
curacy is not a factor. Transient re-
response has also been checked with
pulses of a few millimicroseconds’ rise
time without discernible waveform
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 ar-
range ment indicated in Fig. 4 is con-
venient in that it permits a type UG-
491/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
shielded-cable cable assemblies are also
available to provide a still higher mea-
sure of shielding.

—Arthur Fong and Harley L. Halsverson

SPECIFICATIONS
- hp- MODELS 355A/B
ATTENUATORS
ATTENUATION: - hp - 355A, 12 db in 1 db steps;
- hp - 355B, 10 db in 10 db steps.
FREQUENCY RANGE: - hp - 200 mc to 500 mc.
OVERALL ACCURACY: - hp - 0.25 db, dc
to 200 mc; - hp - 355A, ±1 db, dc to 250 mc,
±2 db, 250 to 500 mc.
NORMAL 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; 330
volts peak.

CONNECTORS: Female type BNC.
WEIGHT: 113/2 lbs. net; shipping weight 3 lbs.
PRICE. - hp - Model 355A $125.00.
- hp - Model 355B, $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

——- hp- MODELS 355A/B
DUAL TRACEROSCILLOSCOPE
Sweep
Sweep Range: 15 calibrated sweeps, accurate
to within ±5%, in 1, 2, 5, 10, ... sequence,
5 μsec/cm to 200 milliseconds/cm. Ver-
nier permits continuous adjustment of sweep
time between calibrated steps and extends
the 200 milliseconds/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 μsec/cm. Expansion is about the
center of the CRT and expanded sweep ac-
curacy is ±10%.
Synchronization: Internally from vertical de-
flection signals causing 1/2 cm or more ver-
tical 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. Turn-
ing fully counter-clockwise into AUTO re-
stores automatic operation.
VERTICAL AMPLIFIERS
Bandwidth: Dc-coupled: Dc to 200 kc.
Ac coupled: 2 cps to 200 kc.
Bandwidth is independent of calibrated sen-
sitivity setting.
Sensitivity: 1 millivolt/cm to 100 volt/cm.
4 calibrated steps accurate within ±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 auto-
matically connected to vertical amplifier for
standardizing at zero input, accuracy ±2%.
Input Impedance: 1 megohm, less than 70 ppf
shunt capacitance.
Phase Shift: Vertical and horizontal amplifiers
have some phase characteristics within ±2°
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 μf common mode
rejection is at least 40 db.
Common mode signal must not exceed ±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 at 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 sen-
sitivity setting.
Sensitivity: 0.1 volt/cm to 100 volt/cm.
3 calibrated steps, accurate within ±5%, 1
v/cm, 10 v/cm, 100 v/cm, and 1000 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 μf.
Prices f.o.b. Palo Alto, California
Data subject to change without notice

A rack-mounting version of the in-
strument (Fig. 5) has been designed with
minimal panel height (7 inches) to
conserv e rack panel area.

Other characteristics of the instru-
m ent are given in the accompanying
specifications.

—John Strathman

GENERAL
Cathode Ray Tube: SAGPI mono-accelerator
normally supplied; 250 cm 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 oscillograph camera and is re-
moved easily for quick change of filter.
CRT Plates: Direct connection to deflection
plates via terminals on rear. Sensitivity ap-
proximately 20 v/cm.
Intensifier Modulator: 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 con-
trolled illumination, 10 cm x 10 cm, marked in
cm squares. Major horizontal and vertical
axes have 2 mm subdivisions.
Dimensions: Cabinet Mount: 20½" wide, 15½"
high, 21½" deep.
Rock Mount: 19½" wide, 7½" high, 21½" deep.
19½" deep behind panel.
Weight: Cabinet Mount: Net 35 lbs., shipping
51 lbs.
Rock Mount: Net 33 lbs., shipping 48 lbs.
Input: 115/230 volts ±10%, 50-1000 cps ap-
proximately 150 watts.
Accessories Available: AC-634 Viewing Hood,
face-fitting molded rubber, Price: $4.30.
Prices: Model 122A Cabinet Mount: $625.00.
Model 122AR Rock 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.

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