

THE SCOPE THAT GIVES BETTER PERFORMANCE

**IN ANY
DIRECTION**



hp 140A/141A PLUG-IN OSCILLOSCOPE

- 20 MHz wideband • 150 ps TDR • 50 μ V/cm sensitivity with no dc drift
- 12.4 GHz sampling • Swept frequency • Variable persistence and storage

HEWLETT  PACKARD
An extra measure of performance



With hp's 140A, you can use
A FULL SPECTRUM OF ADVANCED PLUG-INS
for better performance in any direction

Solve more measurement problems in less time, with greater accuracy, and at a lower overall cost with the hp 140A Oscilloscope System. Turn the page and see.

With hp's 140A you can use a full spectrum of advanced plug-ins for
BETTER PERFORMANCE IN ANY DIRECTION



12.4 GHz Sampling with Delayed Sweep

Exceedingly fast hp switching diodes have opened a true breakthrough in sampling scope capabilities.

For the first time, you can see through X band, observe CW signals to 12.4 GHz and beyond, and see fast pulses with a 28 ps rise time capability. You can also use TDR measurements to resolve discontinuities down to less than 1 cm in the design of cables, coaxial components, connectors and strip lines. In addition, you can utilize delayed sweep through the full bandwidth to get displays of pulse segments that leave conventional sampling scopes blurred. You also get less than 20 ps jitter to ensure steady, clear displays.

Two vertical amplifiers are available. Model 1411A provides dc to 12.4 GHz at 1 mV/cm, dual-channel performance with remote samplers featuring feed-through inputs for minimum signal disturbance. The other sampling vertical amplifier, Model 1410A, gives performance to 1 GHz, with both high-Z probes and 50Ω inputs—and internal triggering. Model 1425A Sampling Time Base plug-in provides delayed sweep, automatic triggering and a movable intensified dot that makes it easy to set up the point of magnification.



50 μV/cm Zero Drift

The versatile hp 140A Scope System gives you five high-sensitivity plug-ins specifically designed for measurement of low-level signals. For example, the 1406A vertical plug-in offers high 50 μV/cm sensitivity with no dc drift—plus precision calibrated dc offset for extreme magnification.

With the hp calibrated offset feature, the 1406A gives you the advantages of a dc and ac voltmeter—four-digit readout, auto decimal placement, better than 0.5% measurement accuracy. As a dc voltmeter, the 1406A offers you the additional advantages of no drift in the measurement instrument, and the ability to observe and measure any ac riding on the dc voltage. With these capabilities you can make measurements never before possible. For example, you can simultaneously display a 10 V dc signal at 50 μV/cm (giving a magnification of 200,000), measure dc level accurately to four digits, see short term dc drift with microvolt resolution, and view and measure all ac ripple—an impossible measurement with a meter. The hp 1406A plug-in also operates as a dc coupled, no drift differential amplifier with 80 dB common mode rejection.



Simplify Design of Microwave & Pulse Circuits with 150 ps TDR

You can use a 1415A Time Domain Reflectometer plug-in to quickly determine the magnitude and nature of each resistive or reactive discontinuity in strip lines or coaxial components such as attenuators, cables, connectors and delay lines. This 150 ps system enables you to resolve discontinuities an inch apart.

The 1415A is a completely self-contained system consisting of a fast-rise pulse generator, single channel sampler, and time base. No additional vertical or horizontal amplifiers are required, thus eliminating introduction of additional chances of error. The vertical channel is calibrated in reflection coefficient for direct readout, with a maximum sensitivity of .005 p/cm for measurement of extremely small discontinuities. Full 10 cm X 10 cm display area gives maximum resolution. Distances can be read directly on the horizontal axis. The compact control panel contains only those controls necessary for TDR measurements, thus making the 1415A much simpler to operate than comparable systems costing twice as much.

Accessories for direct readout in special applications: Rise Time Converters which eliminate reflections beyond the bandwidth of interest, 75Ω adapters, and a Susceptance Standard which gives direct readings of reactive discontinuities.



Get 20 MHz Band- width and Delayed Sweep Readability

If you need wideband performance, for example, you can use the dual-trace 1402A vertical amplifier and get dc to 20 MHz at 5 mV/cm, algebraic addition, built-in delay line for viewing the leading edge of fast-rise pulses, full 6 cm deflection and a wide dynamic range. An internal sync amplifier triggers on Channel A dual trace mode of operation—gives stable traces and accurate time measurements without external triggering.

For easy readability of complex waveforms and accurate time interval measurements, Model 1421A Time Base & Delay Generator provides extreme magnification—calibrated time delays from 10 seconds to 0.5 μsec, calibrated sweep speeds from 1 sec/cm to 20 ns/cm. The 1421A also offers the additional advantage of exclusive hp mixed sweep. This feature combines display of the first portion of a trace at normal sweep speeds, and simultaneously expands the trailing portion of the trace at faster delayed sweep speeds to allow step-by-step magnified examination.



The hp 140A Scope System gives you the extraordinary versatility you need to get step-ahead measurements over the entire oscilloscope spectrum—now and in the years ahead. With 17 high-performance vertical and horizontal plug-ins to choose from, you can head in any measurement direction: wideband, sampling, high-sensitivity or measurements such as time domain reflectometry and swept frequency . . . all with optional variable persistence and storage if you like.

Count these exclusive capabilities: hp's 140A is the ONLY oscilloscope system that gives you sampling bandwidth to 12.4 GHz . . . sampling delayed sweep time base . . . 50 μV/cm sensitivity with no dc drift . . . versatile single- or double-size plug-in capability . . . plus plug-ins for direct readout TDR and swept frequency. In addition, it is the only oscilloscope system to offer either standard CRT persistence in the 140A mainframe—or optional variable persistence and storage in the 141A mainframe. Select from these unique measurement capabilities, or pick the work-horse 20 MHz, 5 mV/cm dual-trace plug-in.



Exclusive Variable Per- sistence and Storage

In addition to plug-in versatility that takes you across the oscilloscope measurement spectrum, you can also get CRT versatility that matches the requirements of any signal. The optional 141A provides trace persistence which is adjustable from 0.2 sec to more than a minute so that you can tune persistence to any signal for bright, steady traces without annoying flicker. The 141A also provides storage for side-by-side comparison of waveforms—and conventional persistence as well. As a result, the 141A gives you continuous control over CRT performance—plus the flexibility of hp's entire 1400 Series plug-ins. See next page for full details.

HEWLETT  PACKARD
An extra measure of performance

Choose From Two hp High-Performance Mainframes:

140A WITH STANDARD CRT OR 141A WITH EXCLUSIVE VARIABLE PERSISTENCE & STORAGE

Both 140A & 141A mainframes enable you to:

- Get clearly superior performance throughout the oscilloscope measurement spectrum from dc to 12.4 GHz
- Use all 17 hp high-performance 1400 Series plug-ins
- Push a button and immediately locate a trace via convenient beam finder
- See brilliant, sharp, steady displays with advanced 7.3 kV CRT
- Get an accurate reading from any angle with no-parallax, internal-graticule CRT

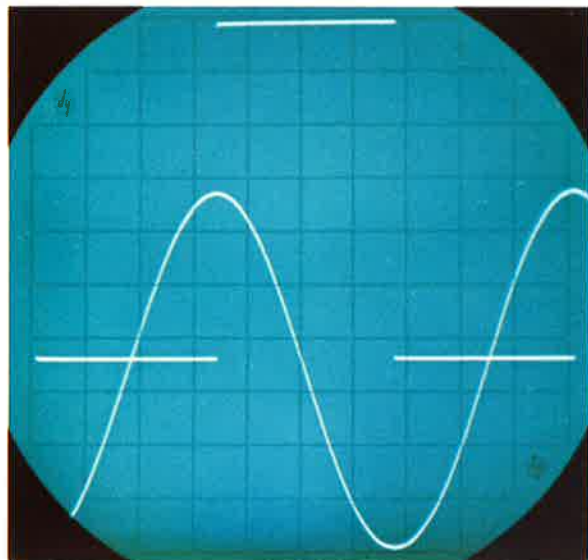
In addition to these advantages, the 141A mainframe also enables you to:

- Match the persistence of your screen to any signal for steady traces without annoying flicker
- Store waveforms for side-by-side comparison

The advanced hp 140A and 141A mainframes give you a choice between conventional (fixed) CRT persistence—and variable persistence & storage. As a result, the 140A/141A system gives you not only an extensive plug-in capability, but also, the CRT versatility you need to meet the requirements of any measurement problem today—six months from now—or at any future time.

These hp 140A and 141A mainframes are specifically designed to give you both high-frequency and high-sensitivity performance. Both consist of the essential functional blocks for low and high frequency applications—plus sampling. Included is a post-accelerator CRT, associated control circuitry, power supplies, and the dc supplies required to power the hp 1400 Series plug-ins which contain CRT drive circuitry.

In the hp 140A CRT, you get high 7.3 kV electron beam acceleration for bright, easy-to-see traces... internal graticule eliminates parallax... carefully shaped post accelerator field gives full 10 cm X 10 cm display area without distortion.



This true building-block arrangement assures that you can use existing and future plug-ins without modification to the mainframe. You pay only for the circuitry you actually need to make your particular measurements.

Because all deflection circuitry is contained the plug-ins, you get exclusive capabilities in mixing plug-ins. You can not only select the amplifier you need for the vertical axis, but also, you can select the particular time base generator needed for the horizontal axis.

Further, since the 140A and 141A CRT's have identical horizontal and vertical deflection sensitivities, you can use two vertical amplifiers for an X-Y display... or one single-channel amplifier and one dual-channel amplifier to plot two variables against a third... or two identical dual-channel amplifiers for a pair of simultaneous X-Y displays.

Or, you can remove the shield which separates upper and lower plug-in compartments and use double-size plug-ins such as the hp Model 1415A Time Domain Reflectometer, or Model 1416A Swept Frequency Indicator.

Both 140A and 141A mainframes are equipped with a convenient beam finder which quickly locates a trace and puts it on screen for fast trouble-free set-up.

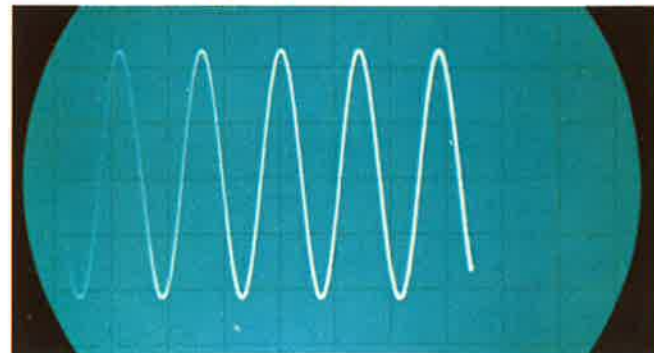
Price: hp 140A, \$595; hp 141A, \$1395.

Exclusive 141A: Variable Persistence and Storage Make It...

THE SCOPE WITH AN ADJUSTABLE MEMORY

The 141A mainframe gives you all the advantages of the 140A mainframe—plus the exclusive benefits of hp variable persistence and storage.

The hp 141A has a 7.3 kV, post accelerator CRT—with unique mesh storage. At the twist of a knob, you can adjust the 141A's memory span (trace persistence) from 0.2 seconds to a minute... to hours

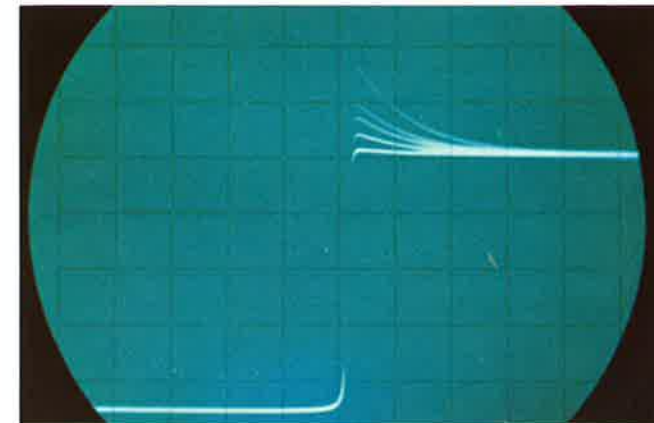


Exclusive hp variable persistence enables you to match the persistence of your CRT screen to any signal—eliminating annoying flicker on slow signals such as swept frequency and sampling waveforms, transducer signals and low-frequency displays.

... to days. This exclusive hp variable persistence allows you to adjust the CRT persistence to match the changing characteristics of a signal—any necessary number of traces can be held for trend comparisons, or for flicker-free displays. With a bi-stable storage tube, all information is stored, often creat-

ing jumbled displays—or you have flickering "full" erase and no retained information.

The hp mesh storage tube offers many advantages. With the 141A CRT, the stored trace has the same high contrast as a conventional CRT. Intermediate trace values stand out clearly, you can easily distinguish between four or five separate trace intensities—as opposed to the limiting black-and-white-only displays of ordinary bi-stable storage. Intensity of the 141A CRT can be varied by a front panel control, or modulated externally for X-Y presentations. Maximum viewing intensity in store-view mode is 200 foot lamberts—25 times brighter than bi-stable tubes. With the hp storage mesh CRT,

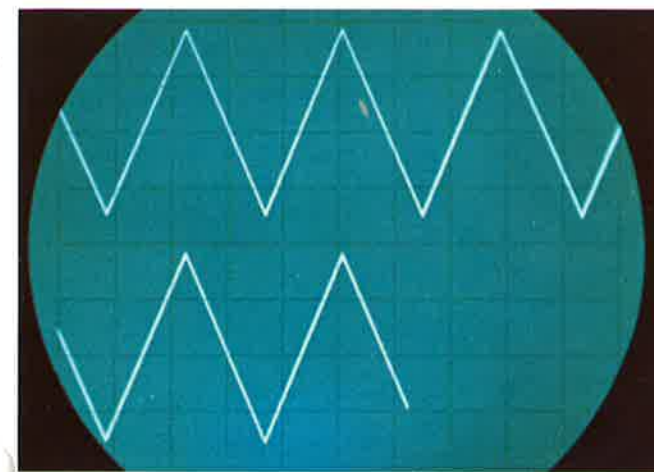


See signal trends while making circuit adjustments by simply making persistence long enough so that several traces appear on screen simultaneously.

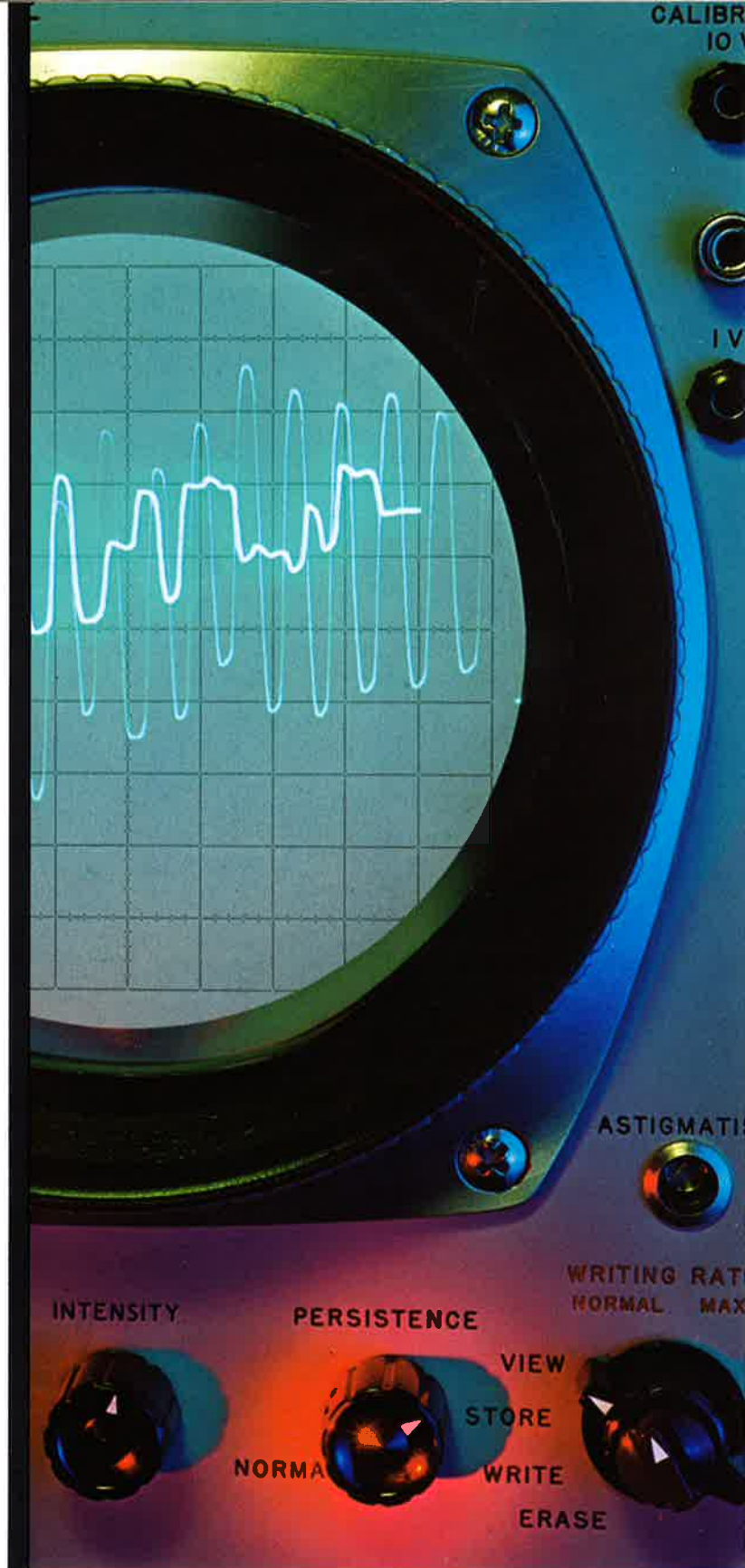
trace brightness and writing speed are maintained over the entire life of the tube—specified performance is warranted for one year.

In addition to conventional storage, the 141A CRT is also capable of storage after power has been turned off. This feature permits a graphic display of some critical parameter prior to (a) system failure, (b) activation of a safety device, or (c) excursions beyond some predetermined limit. As much as a full minute of information can be stored in this manner for days.


















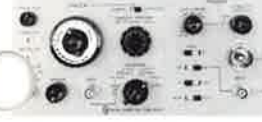
Utilize the hp 141A scope for variable persistence, conventional persistence, and storage—it's like having three scopes in one! Also, you have the advantage of choosing from any of the hp high-performance 1400 Series plug-ins.



The 141A gives you storage for side-by-side comparison of waveforms. In this mode, traces can be held intact for more than an hour (days, in fact, with the scope turned off). Fast 1 cm/μsec storage writing rate enables you to capture single-shot transients.



The advanced hp 141A mainframe gives you three scopes in one: variable persistence, conventional (fixed) persistence, and storage—plus the ability to accommodate any of hp's high-performance 1400 Series plug-ins. You get better performance throughout the oscilloscope measurement spectrum from dc to 12.4 GHz—and meet any existing or future measurement requirement.

 <p>1400A Pg. 14</p> <ul style="list-style-type: none"> • 100 μV/cm • dc to 400 kHz • Differential on all ranges <p>\$250</p>	 <p>1406A Pg. 13</p> <ul style="list-style-type: none"> • 50 μV/cm — dc to 400 kHz • No drift • Calibrated offset for accurate ac & dc measurements <p>\$850</p>	 <p>1420A Pg. 16</p> <ul style="list-style-type: none"> • 10 MHz triggering • Sweeps to 50 ns/cm • Auto triggering <p>\$325</p>	 <p>1425A Pg. 25</p> <ul style="list-style-type: none"> • Delayed sweep • Sweeps to 10 ps/cm • Triggering to 1 GHz <p>\$1600</p>
 <p>1401A Pg. 14</p> <ul style="list-style-type: none"> • 1 mV/cm — dual trace • dc to 450 kHz • Convenient dual trace triggering <p>\$425</p>	 <p>1407A Pg. 15</p> <ul style="list-style-type: none"> • 50 μV/cm • No drift • 80 dB common mode rejection <p>\$625</p>	 <p>1421A Pg. 17</p> <ul style="list-style-type: none"> • 20 MHz triggering • Delayed sweep • Sweeps to 20 ns/cm <p>\$625</p>	 <p>1415A Pg. 28</p> <ul style="list-style-type: none"> • Complete TDR system for testing cables, connectors, striplines • Determines location, magnitude, and nature of each discontinuity • Resolves discontinuities — an inch apart • Easy to operate <p>\$1050</p>
 <p>1402A Pg. 11</p> <ul style="list-style-type: none"> • 5 mV/cm • dc to 20 MHz — dual trace • Signal delay for fast rise viewing <p>\$575</p>	 <p>1410A Pg. 18</p> <ul style="list-style-type: none"> • 1 mV/cm at 1 GHz — dual trace • Internal triggering • High impedance probes and 50 Ω inputs <p>\$1600</p>	 <p>1422A Pg. 16</p> <ul style="list-style-type: none"> • 500 kHz triggering • Sweeps to 200 ns/cm • Auto triggering <p>\$225</p>	
 <p>1403A Pg. 15</p> <ul style="list-style-type: none"> • 10 μV/cm • 0.1 Hz to 400 kHz • 106 dB common mode rejection <p>\$475</p>	 <p>1411A Pg. 20</p> <ul style="list-style-type: none"> • 1 mV/cm — dual trace • Bandwidths to 12.4 GHz • Remote samplers <p>\$700</p>	 <p>1423A Pg. 16</p> <ul style="list-style-type: none"> • 20 MHz triggering • Sweeps to 20 ns/cm • Trigger hold-off <p>\$450</p>	 <p>1416A Pg. 27</p> <ul style="list-style-type: none"> • Speeds and simplifies swept frequency measurements • High resolution readout directly in dB • Low drift • X-Y recorder outputs <p>\$675</p>
 <p>1405A Pg. 12</p> <ul style="list-style-type: none"> • 5 mV/cm — dual trace • dc to 5 MHz • Algebraic addition <p>\$325</p>	 <p>1430A Pg. 21 1431A Pg. 21 1432A Pg. 20</p> <ul style="list-style-type: none"> • 28 ps rise time — \$3000 • 12.4 GHz bandwidth — \$1000 • 90 ps rise time — \$1000 	 <p>1424A Pg. 24</p> <ul style="list-style-type: none"> • Triggering to 5 GHz • Sweeps to 10 ps/cm • Direct readout on all sweeps <p>\$1200</p>	

hp's 1400 Series  *plug-ins cover the measurement spectrum from dc to 12.4 GHz*

FOR BETTER PERFORMANCE IN ANY DIRECTION

CAPABILITIES	VERTICAL PLUG-INS									COMPATIBLE TIME BASES								DOUBLE SIZE PLUG-INS		
	1400A	1401A	1402A	1403A	1405A	1406A	1407A	1410A	1411A	1430A	1431A	1432A	1420A	1421A	1422A	1423A	1424A	1425A	1415A	1416A
1. Wide Band			•		•								•	•		•				
2. Sampling								•	•	•	•									
3. High Gain Differential	•			•		•	•						•	•	•	•				
4. Dual Trace		•	•		•			•	•				•	•	•	•	•			
5. X-Y	•	•	•	•	•	•	•	•	•											
6. Delayed Sweep		1421A for real time				1425A for sampling														
7. No Drift						•	•						•	•	•	•				
8. High Common Mode Rejection				•		•	•						•	•	•	•				
9. Algebraic Addition		•	•		•			•	•				•	•	•	•	•			
10. Time Domain Reflectometry										•									•	
11. Wide Band TDR																				•
12. Swept Frequency																				•

MAIN FRAME SPECIFICATIONS

Model 140A Specifications

Plug-ins: accepts Model 1400-series plug-ins; upper compartment for horizontal axis and lower compartment for vertical axis; center shield may be removed to accommodate a single dual-axis Model 1400-series unit.

Cathode-ray tube:

Type: post-accelerator, 7300-volt accelerating potential; aluminized P31 phosphor (other phosphors available, see modifications); etched safety glass face plate reduces glare.

Graticule: 10 cm x 10 cm parallax-free internal graticule marked in cm squares; major horizontal and vertical axes, and second and tenth horizontal graticule lines have 2 mm subdivisions.

Intensity modulation: ac coupled, +20 volt pulse will blank trace of normal intensity; input terminals on rear panel.

Warranty: CRT warranted for one year.

Writing rate: (using HP Model 197A Camera with f/1.9 lens and Polaroid® 3000 speed film).

P31 Phosphor: 300 cm/μsec.

P11 Phosphor: 430 cm/μsec.

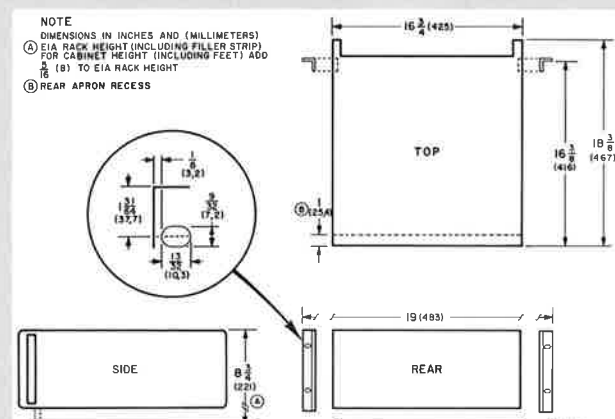
Calibrator:

Type: line-frequency rectangular signal, approximately 0.5 μsec rise time.

Voltage: two outputs: 1 volt and 10 volts peak-to-peak, ±1% from 15°C to 35°C, ±3% from 0°C to 55°C.

Beam finder: pressing beam finder control brings trace on CRT screen regardless of settings of horizontal, vertical or intensity controls.

Power requirements: 115 or 230 volts ±10%, 50 to 60 Hz, normally less than 285 watts (varies with plug-in units used).



Weight: without plug-ins, net 37 lbs (16.7 kg); shipping 45 lbs (20 kg).

Price: HP Model 140A (without plug-ins), \$595.

Modifications: CRT phosphors (specify by phosphor number), P31 standard; P2, P7 with amber filter, P11 available; no charge.

Special order: chassis slides and adapter kits; fixed slides, order HP Part No. 1490-0714, \$32.50; pivot slides, order HP Part No. 1490-0178, \$40; slide adapter kit for mounting slides on scope, order HP Part No. 1490-0721, \$20.

“Polaroid”® by Polaroid Corporation

Model 141A Specifications

Plug-ins: same as Model 140A.

Cathode-ray tube:

Type: post-accelerator storage tube, 7300-volt accelerating potential; aluminized P31 phosphor; etched safety glass face plate reduces glare.

Graticule: 10 x 10 divisions (approximately 9.4 x 9.4 cm) parallax-free internal graticule; 5 subdivisions per major division on major horizontal and vertical axes, and on second and tenth horizontal graticule lines.

Intensity modulation: ac coupled, + 20 volt pulse will blank trace of normal intensity; input terminals on rear panel.

Warranty: CRT specifications (persistence, writing rate, brightness, storage time) warranted for one year.

Persistence:

Normal: natural persistence of P31 phosphor (approximately 0.1 second).

Variable:

Normal writing rate mode: continuously variable from less than 0.2 second to more than one minute (typically to two or three minutes).

Max writing rate mode: typically variable from 0.2 second to 15 seconds.

Erase: manual; erasure takes approximately 100 msec; scope ready to record immediately after erasure (see options for remote erase).

Writing rate (conventional operation): (using HP Model 197A Camera with f/1.9 lens and Polaroid® 3000 speed film): 100 cm/μsec.

Writing rate (Storage):

Normal mode: greater than 20 cm/msec.

Max. mode: greater than 1 cm/μsec.

Storage time:

	NORMAL Writing Rate Mode	MAX. Writing Rate Mode
STORE Mode (dim display)	longer than 1 hour	typically 15 minutes
VIEW Mode (bright display)	longer than 1 minute (typically 2 or 3 minutes)	typically 15 seconds

Brightness: greater than 100 foot-lamberts in NORMAL or VIEW; typically 5 foot-lamberts in STORE.

Calibrator:

Beam finder:

Power requirements: } same as Model 140A

Dimensions:

Weight: net, 40 lbs (18 kg); shipping, 51 lbs (23 kg).

Price: HP Model 141A (without plug-ins), \$1395.00.

Options: (specify by option number).

09: Remote erase. BNC input on rear panel; shorting to ground for at least 50 msec erases screen; input draws 20 mA from ground through a 600-ohm impedance to a -12 volt supply. Add \$25.

Special order: chassis slides and adapter kit; fixed slides, order HP Part No. 1490-0714, \$32.50; pivot slides, order HP Part No. 1490-0718, \$40; slide adapter kit for mounting slides on scope, order HP Part No. 1490-0721, \$20.

“Polaroid”® by Polaroid Corporation

WIDE BAND AMPLIFIER

1402A DUAL TRACE AMPLIFIER



- 5 mV/cm
- dc to 20 MHz
- Algebraic addition of channels
- Signal delay for fast-rise viewing
- Convenient dual trace triggering

Description

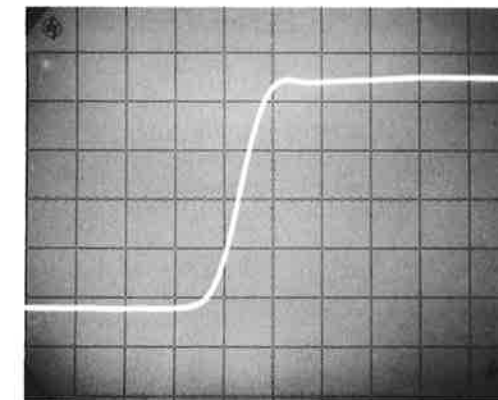
The 1402A Dual Trace Amplifier provides greater than 20 MHz bandwidth plus 5 mV/cm sensitivity on each channel for accurate analysis of high frequency low level signals. Rise times of signals can be easily measured because the 1402A has a built-in delay line in the vertical amplifier following the trigger take-off.

Two signals can be displayed with the 1402A in each of two modes. Slow signals can be viewed in the chopped mode, since the input to the CRT is switched between Channel A and Channel B at a high rate during each sweep. Fast signals can be viewed in the alternate mode since the input to the CRT is switched at the end of each sweep, with Channel A displayed during one sweep and Channel B on the following sweep.

Accurate time difference measurements are possible because the sync amplifier in the 1402A can be switched to Channel A alone. This feature is useful when dual traces are displayed on alternate sweeps; switching the sync to Channel A preserves the time relationship between the two signals, because the sweep always triggers on the same point on Channel A. Also, syncing to Channel A when in the chopped dual trace mode assures triggering on the displayed waveform rather than the chopper. Two unrelated signals can be displayed by triggering on the composite waveform. This feature avoids resorting to external triggering for either of these dual trace presentations.

Single-channel displays are also possible for either input A or B. The two channels may also be displayed algebraically added, and a polarity reversal switch on Channel A allows the differential signal, B—A, to be displayed.

Although maximum bandwidth is obtained from the 1402A with 6 cm or less deflection, larger amplitude signals can be displayed without distortion and with only a small sacrifice in bandwidth. For example, the bandwidth when using a full 10-cm deflection is greater than 15 MHz.



Above photo demonstrates bandwidth and excellent transient response of 1402A Dual Trace Amplifier. Sweep time is 20 ns/cm; sensitivity is 5 mV/cm.

Specifications

Mode of operation: (1) Channel A alone, (2) Channel B alone, (3) Channel A and Channel B displayed on alternate sweeps, (4) Channel A and Channel B displayed by switching at approx. 100 kHz, with trace blanking during switching, (5) Channel A and Channel B added algebraically, polarity of Channel A may be inverted to obtain differential operation.

Bandwidth: (6 cm reference signal) dc coupled, dc to 20 MHz; ac coupled, 2 Hz to 20 MHz.

Risetime: less than 20 nsec with 6 cm step input.

Deflection factor (sensitivity): each channel; 5 mV/cm to 10 V/cm, 11 ranges in a 1, 2, 5 sequence; accuracy ±3%; vernier provides continuous adjustment be-

tween steps and extends 10 V/cm step to at least 25 V/cm.

Signal delay: signal is delayed so that leading edge of fast-rise signals is visible at start of sweep.

Common mode rejection: (in B-A mode) at least 40 dB on 5, 10, and 20 mV/cm ranges, at least 30 dB on 50 mV/cm to 10 V/cm ranges; common mode signal not to exceed 150 cm (e.g., 150 volts on 1 V/cm range) or a frequency of 500 kHz.

Input RC: 1 megohm shunted by 43 pF.

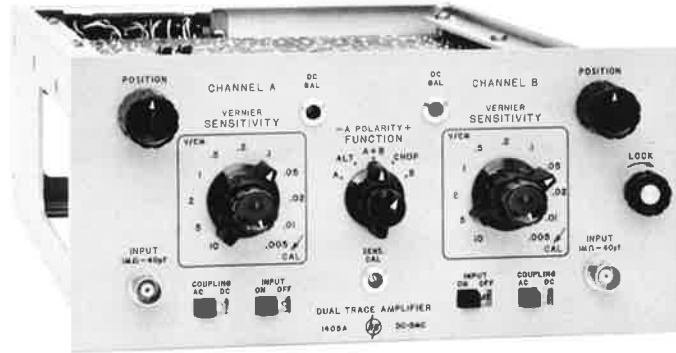
Maximum input: 600 volts peak (dc + ac).

Weight: net, 6 lbs (2.7 kg); shipping, 8 lbs (3.6 kg).

Price: HP Model 1402A, \$575.

WIDE BAND AMPLIFIER

1405A DUAL TRACE AMPLIFIER



- 5 mV/cm
- dc to 5 MHz
- Algebraic addition
- Full 10 cm deflection
- Wide dynamic range

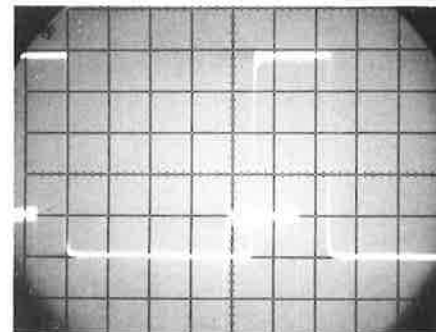
Description

The 1405A Dual Trace Amplifier provides 5 MHz bandwidth at 5 mV/cm sensitivity. Dual trace presentations can be displayed on alternate sweeps or by chopping between the two input signals on the same sweep at a 100 kHz rate. In addition to single-trace presentations of Channel A or B, the two channels may be algebraically added or, by a reversal of the Channel A polarity switch, the differential signal may be viewed. The full 5 MHz frequency response is achieved in every operating mode, and when operating in any sensitivity position.

In all operating modes each channel has independent positioning and sensitivity controls, permitting the comparison of signals with widely differing amplitudes. When used as a differential amplifier, a common-mode rejection of better than 40 dB in the higher sensitivity positions permits the display of low-level signals while attenuating undesirable components such as hum.

The wide dynamic range of the 1405A permits a 50 cm peak-to-peak signal to be displayed without significant distortion. Using A + B mode and a variable dc voltage source such as the 723A power supply applied to the second channel, any 10-cm segment of the 50-cm trace can be positioned on screen and analyzed. The 1405A is an ideal tool for video waveforms when

used with the 1421A Time Base and Delay Generator, since any single line of a television frame may be isolated and displayed. The 5 mV/cm sensitivity permits the display of signals in low-level stages, or permits the use of attenuator probes to prevent circuit loading. For X-Y measurements, such as phase shift or Lissajous patterns, the 1405A may be used with any other 1400 series plug-in (including another 1405A) for either vertical or horizontal deflection.



Double exposure showing 5-cm pulse on upper waveform, and the same pulse expanded 10 X to view small perturbation on the top.

Specifications

Mode of operation: (1) Channel A alone, (2) Channel B alone, (3) Channel A and Channel B displayed in alternate sweeps, (4) Channel A and Channel B displayed by switching at approx. 100 kHz, with trace blanking during switching, (5) Channel A and Channel B added algebraically, polarity of Channel A may be inverted to obtain differential operation.

Bandwidth: dc coupled, dc to 5 MHz (70 nsec rise time; ac coupled, 2 Hz to 5 MHz (the lower limit is extended to approx. 0.2 Hz with a X10 probe).

Deflection factor (sensitivity): each channel; 5mV/cm to 10 V/cm, 11 ranges in a 1, 2, 5 sequence; accuracy

±3%; vernier provides continuous adjustment between steps and extends 10 V/cm step to at least 25 V/cm. **Common mode rejection:** at least 40 dB on 5, 10, and 20 mV/cm ranges, at least 30 dB on 50 mV/cm to 10 V/cm ranges; common mode signal not to exceed 50 cm (e.g., 0.5 volt on 10 mV/cm range) or a frequency of 50 kHz.

Input RC: 1 megohm shunted by 43 pF. **Maximum input:** 600 volts peak (dc + ac). **Weight:** net, 4 lbs (1.8 kg); shipping, 7 lbs (3.2 kg). **Price:** HP Model 1405A, \$325. **Special order:** double-size, single-channel, X-Y only version of Model 1405A; order K05-1405A; price, \$325.

PRECISION AC & DC AMPLIFIER



1406A

- 50 uV/cm
- dc to 400 kHz
- dc stabilized (no drift)
- Calibrated offset for accurate ac & dc measurements

Description

In addition to 50 μ V/cm sensitivity, no drift dc stabilization, and wide dynamic range, the 1406A offers a calibrated dc offset for better than 0.5% accurate ac and dc voltage measurements.

Accurate measurements are accomplished by inserting the test signal into one side of a high common mode rejection differential amplifier and a very accurate (.15%) dc level into the other side. The top of the waveform is then positioned to center screen with the offset controls and the offset reading noted. This is then repeated for the bottom of the waveform. The difference between the two offset readings is the ac amplitude.

The same technique is used when measuring a dc level except only one reading is required; zero volts is already established because the stabilizer eliminates drift.

The range switching is interlocked with the sensitivity switching so that the direct reading offset does not change when changing the sensitivity. There are ten offset ranges providing ± 1 v to ± 1000 v in decade steps.

The 1406A can also be used as a differential amplifier. The high common mode rejection and no drift features provide for accurate differential measurements. An external ground is also provided to eliminate ground loops.

The adjustable bandwidth control of the 1406A allows the user to reduce bandwidth from the maximum of 400kHz down to 100, 25, 5kHz, eliminating noise present in the unused part of the bandwidth. The front panel amplifier output permits driving external equipment such as X-Y recorders or tape recorders.

Specifications

Sensitivity: 50 μ V/cm to 20 v/cm in a 1, 2, 5 sequence. Vernier provides continuous adjustment between ranges and extends minimum sensitivity to at least 50 v/cm. Attenuator accuracy is $\pm 3\%$.

Amplifier output: Approx. 1v/cm, dc coupled, single ended, DC level approx. 0 volts, output impedance less than 100 ohms, dynamic range ± 5 v.

Bandwidth:
Upper limit:
20 v/cm to 100 μ V/cm-400 kHz (0.9 μ s rise time)
50 μ V/cm-300 kHz
Upper limits of MAX, 100, 25, and 5 kHz selectable with front panel switch on all sensitivities.

Lower limit: DC with input DC coupled, 2 Hz with input AC coupled.

Drift:
Long-term drift: Less than ± 0.2 cm or less than ± 20 μ v per 200 hrs, whichever is greater.

Temperature drift: Less than ± 0.2 cm or less than ± 50 μ v, whichever is greater over a temperature range of 0°C to 55°C.

Drift correction occurs at 3 Hz for 50 ms/cm sweeps and faster, and 1.5 Hz on 0.1 s/cm sweeps and slower.

Range to range shift: DC stabilization maintains a fixed baseline reference within ± 1 cm on CRT over entire range of sensitivity after a 3-minute warmup.

Positioning: Baseline can be positioned ± 10 cm by continuous position.

DC offset: Offset is applied to the B (-) input. **Readout:** 4-digit resolution, with lighted decimal indicators.

Ranges: ± 0.1 v, ± 1 v, ± 10 v, ± 100 v, ± 1000 v. Up to ± 10 v offset can be used on all sensitivity ranges; an equivalent ± 100 v range can be used from 0.5 mV/cm through 20 v/cm, and an equivalent ± 1000 v range from 5 mV/cm through 20 v/cm.

Accuracy: $\pm 0.15\%$ of indicated value plus 0.05% of full scale offset range, on ± 0.1 v, ± 1 v, and ± 10 v ranges. $\pm 0.4\%$ of indicated value plus 0.05% of full scale offset range, on ± 100 v and ± 1000 v ranges.

Differential input: May be selected on all sensitivity ranges. Single-ended operation is used when employing offset.

Common mode rejection: (± 5 v pk-pk input, DC coupled, 50 μ V/cm to 20 mv/cm)
dc to 60 Hz—80 db
60 Hz to 10 kHz—60 db

Maximum input without overload:
50 μ V/cm to 20 mv/cm— ± 10 v pk-pk
50 mv/cm to 2 v/cm— ± 100 v pk-pk
5 v/cm to 20 v/cm— ± 600 v pk-pk

Dynamic range: Dynamic signals of at least ± 50 cm of deflection can be displayed without distortion.

Input impedance: 1 megohm shunted by 100 pf, constant on all attenuator ranges.

Max input:
V_o range: .1-10
15 v (DC + peak AC), .05 mv/cm to 20 mv/cm;
150 v, 50 mv/cm to .2 v/cm; 600 v, .5 v/cm to 20 v/cm.

V_o range: 100
150 v (DC + peak AC)

V_o range: 1000
600 v (DC + peak AC)

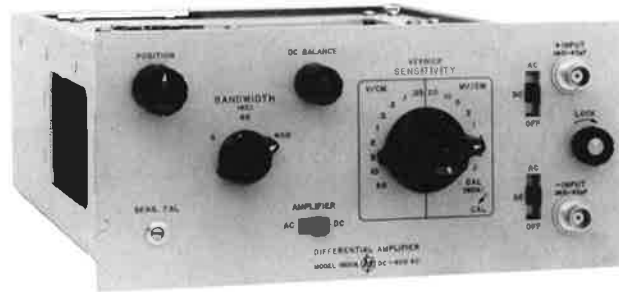
X-Y operation: Two 1406A's can be used to give stabilized X-Y presentation.

Time base compatibility: The 1406A and 1407A can be used directly with the 1422A and 1423A; 1420's below serial 441-01326 and 1421A's below serial 545-00651 must be modified. (Order kits 01420-69502 for the 1420A, 01421-69501 for the 1421A.)

Weight: Net, 5 lbs (1.8 kg); shipping, 7 lbs (3.2 kg). **Price:** \$850.

HIGH SENSITIVITY AMPLIFIERS

1400A



- 100 $\mu\text{V}/\text{cm}$
- dc to 400 kHz
- Selectable bandwidth
- Differential on all ranges
- Low drift

1401A



- 1 mV/cm
- dc to 450 kHz
- Convenient dual trace triggering
- Low drift
- Two independent X-Y displays using two plug-ins

Specifications

1400A

Bandwidth:

Upper limit: 400 (0.9 μsec rise time), 40 or 4 kHz.

Lower limit: Input and Amplifier coupling set to dc; Input set to dc and Amplifier set to ac: dc from 20 V/cm to 50 mV/cm, approx. 0.1 Hz to 20 mV/cm increasing with deflection factor to approx. 20 Hz at 0.1 mV/cm; Input set to ac and Amplifier set to dc: 2 Hz.

Deflection factor (sensitivity): 100 $\mu\text{V}/\text{cm}$ to 20 V/cm, 17 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends 20 V/cm step to at least 50 V/cm.

Phase shift: when used with another Model 1400A, less than 2° relative phase shift up to 50 kHz with X and Y deflection factors the same, and verniers in Cal.

Common mode rejection: differential input may be selected on all ranges; CMR at least 40 dB on 0.1 mV/cm to 0.2 V/cm ranges, signal not to exceed 4 V pk-pk; at least 30 dB on 0.5 V/cm to 20 V/cm ranges, signal not to exceed 40 V pk-pk on 0.5, 1, and 2 V/cm ranges or 400 V pk-pk on 5, 10, and 20 V/cm ranges, measured with 1 kHz sine wave.

Input RC: 1 megohm shunted by 45 pF.

Maximum input: 600 volts peak (dc + ac).

Internal calibrator: line frequency square wave, 6 cm pk-pk; displayed when vernier is set to Cal; accuracy $\pm 3\%$.

Weight: net, 4 lbs (1.8 kg); shipping, 7 lbs (3.2 kg).

Price: HP Model 1400A, \$250.

Mode of operation: (1) Channel A alone, (2) Channel B alone, (3) Channel A and Channel B displayed on alternate sweeps, (4) Channel A and Channel B displayed by switching at approx. 100 kHz, with trace blanking during switching, (5) Channel A minus Channel B.

1401A

Bandwidth: Input and Amplifier coupling set to dc, dc to 450 kHz (0.8 μsec rise time); Input set to dc and Amplifier set to ac, dc to 450 kHz for deflection factors from 50 mV/cm to 10 V/cm; from 1 mV/cm to 20 V/cm, lower cutoff depends on the deflection factor: approximately 0.5 Hz (to 450 kHz) at 20 mV/cm and 10 Hz (to 450 kHz) at 1 mV/cm; Input set to ac and Amplifier set to dc, 2 Hz to 450 kHz.

Deflection factor (sensitivity): each channel; 1 mV/cm to 10 V/cm, 14 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends 10 V/cm step to at least 25 V/cm.

Phase shift: when used with another Model 1401A, less than 2° relative phase shift up to 50 kHz with X and Y deflection factors the same, and verniers in Cal.

Common mode rejection: both inputs may be switched to one channel to give differential input; cmr at least 40 dB on 1 mV/cm to 0.1 V/cm ranges, signal not to exceed 4 V pk-pk; at least 30 dB on 0.2 V/cm to 10 V/cm ranges, signal not to exceed 40 V pk-pk on 0.2, 0.5, and 1 V/cm ranges or 400 V pk-pk on 2, 5 and 10 V/cm ranges; measured with 1 kHz sine wave.

Input RC: 1 megohm shunted by 45 pF.

Maximum input: 60 volts peak (dc + ac).

Internal calibrator: line frequency square wave, 6 cm pk-pk; displayed when vernier is set to Cal; accuracy $\pm 3\%$.

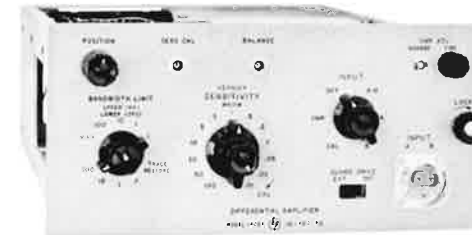
Display polarity: + up or - up, selectable, 7 lbs (3.2 kg).

Weight: net, 5 lbs (2.3 kg); shipping 7 lbs (3.2 kg).

Price: HP Model 1401A, \$425.

HIGH SENSITIVITY AMPLIFIERS

1403A



- 10 $\mu\text{V}/\text{cm}$
- 106 dB common mode rejection
- Guarded input

1407A



- 50 $\mu\text{V}/\text{cm}$
- No drift
- 80 dB common mode rejection

Specifications

1403A

Input modes: (1) input A single-ended, (2) input B single-ended and inverted, (3) A-B differential, (4) Off disconnects inputs and grounds input amplifier, (5) CMR and (6) Cal for calibrating the instrument; A and B inputs, guard, and chassis ground are brought out through a special guarded connector; guard is normally driven by internal common mode signal amplifier; with unbalanced source impedances, the guard may be driven externally, preserving high CMR.

Bandwidth: 0.1 Hz to 400 kHz (0.9 μsec rise time) (to 200 kHz at 10 $\mu\text{V}/\text{cm}$ and to 300 kHz at 20 $\mu\text{V}/\text{cm}$); upper and lower limits may be independently selected; lower: 0.1, 1, 10, and 100 Hz; upper: max (greater than 400 kHz), 100, 10, 1, and 0.1 kHz.

Deflection factor (sensitivity): 0.01 mV/cm to 100 mV/cm, 13 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends 100 mV/cm step to at least 125 mV/cm.

Phase shift: when used with another Model 1403A, less than 2° relative phase shift up to 50 kHz with X and Y deflection factors the same, and verniers in Cal.

Common mode rejection: differential input may be selected on all ranges; with a balance input impedance and the Guard Drive in Ext, CMR may be adjusted to the values below for up to 5 V pk-pk, 45 Hz to 3 kHz (for Int. CMR is 6 dB less than shown below).

Deflection factor (mV/cm)	Common mode rejection (dB)
0.01 to 0.2	106
0.5, 1, 2	86
5, 10, 20	66
50, 100	46

Typical CMR with an unbalanced source impedance when using Guard Drive Ext on most sensitive ranges:

Unbalance	60 Hz	120 Hz	1 kHz	10 kHz
100 ohms	100 dB	100 dB	100 dB	90 dB
1 k ohms	100 dB	100 dB	90 dB	70 dB
10 k ohms	80 dB	80 dB	70 dB	50 dB

Input RC: 10 megohms shunted by approx. 60 pF.

Maximum input: 600 volts peak (dc + ac) on A and B inputs, 10 volts on Guard input.

Noise: 20 μV pk-pk at 100 kHz, noise is reduced as bandwidth is reduced.

Internal calibrator: line frequency square wave, 100 mV pk-pk; displayed when input selector is set to Cal; accuracy $\pm 3\%$.

Weight: net, 4 lbs (1.8 kg); shipping, 7 lbs (3.2 kg).

Accessories furnished: 6-ft double-shielded extension cable, and a 4-terminal binding post adapter.

Price: HP Model 1403A, \$475.

1407A

Bandwidth:

Upper limit: selectable; 5, 25, 100 kHz, and max (400 kHz for 20 V/cm to 100 $\mu\text{V}/\text{cm}$ ranges, 0.9 μsec rise time; or 300 kHz for 50 $\mu\text{V}/\text{cm}$ range).

Lower limit: dc coupled input, dc; ac coupled input, 2 Hz.

Deflection factor (sensitivity): 50 $\mu\text{V}/\text{cm}$ to 20 V/cm, 17 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends 20 V/cm step to at least 50 V/cm.

Amplifier output: approx. 1 V/cm, dc coupled, single-ended, dc level approx. 0 V, output impedance less than 100 ohms, dynamic range ± 5 V.

Drift: drift correction occurs at 3 Hz for 50 msec/cm speeds and faster, 1.5 Hz on 0.1 sec/cm speeds and slower.

Long term drift: less than ± 0.2 cm or less than ± 20 $\mu\text{V}/200$ hours, whichever is greater.

Temperature drift: less than ± 0.2 cm or less than ± 50 μV , whichever is greater, over a temperature range of 0°C to 55°C.

Range to range shift: dc stabilization maintains a fixed baseline reference within ± 1 cm on crt over entire deflection factor range, after a 3-minute warm-up.

Positioning: baseline can be positioned continuously or in calibrated steps of 0, ± 5 cm, and ± 10 cm; accuracy $\pm 3\%$.

DC offset: uncalibrated dc offset is provided in both single-ended and differential operation; the max amount of offset obtainable, referenced to the input, varies with deflection factor approx. as follows: 0.2 V at 50 $\mu\text{V}/\text{cm}$, increasing to 0.5 V at 10 mV/cm, 5 V at 100 mV/cm, 50 V at 1 V/cm, and 600 V at 20 V/cm; offset dc drift is less than ± 20 $\mu\text{V}/\text{hr}$ at constant ambient temperature, or less than ± 100 μV for ambient temperature change of 0°C to 55°C.

Differential input: may be selected on all ranges; offset capability is maintained in differential operation.

Common mode rejection: (± 5 V pk-pk input, dc coupled, 50 $\mu\text{V}/\text{cm}$ to 20 mV/cm) dc to 60 Hz, 80 dB; 60 Hz to 10 kHz, 60 dB; max input without overload: 50 $\mu\text{V}/\text{cm}$ to 20 mV/cm, ± 10 V pk-pk; 50 mV/cm to 2 V/cm, ± 100 V pk-pk; 5 V/cm to 20 V/cm, ± 600 V pk-pk.

Dynamic range: dynamic signals of less than ± 50 cm of deflection can be displayed without distortion.

Input RC: 1 megohm shunted by 90 pF.

Maximum input: 100 volts peak (dc + ac) for 0.5 mV/cm to 20 mV/cm ranges, 600 volts peak (dc + ac) for 50 mV/cm to 20 V/cm ranges.

X-Y operation: two Model 1407A's can be used to provide stabilized X-Y presentations.

Time base compatibility: the Model 1407A may be used directly with Models 1422A and 1423A; Model 1420A's below serial 441-01326, and Model 1421A's below serial 545-00651 must be modified for use with the Model 1407A (order kits 01420-69502 for the Model 1420A, \$12.50; or 01421-69501 for the Model 1421A, \$20).

Weight: net, 5 lbs (1.8 kg); shipping 7 lbs (3.2 kg).

Price: HP Model 1407A, \$625.

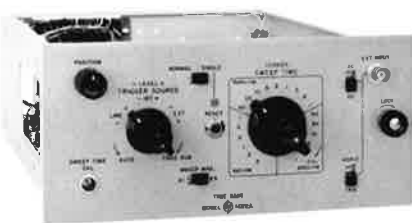
TIME BASES

1420A



- 10 MHz triggering
- Sweeps to 50 ns/cm
- Automatic triggering

1422A



- 500 kHz triggering
- Sweeps to 200 ns/cm
- Automatic triggering

1423A



- 20 MHz triggering
- Sweeps to 20 ns/cm
- Trigger hold-off

Specifications

Range: 0.5 μ sec/cm to 5 sec/cm, 22 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends the 5 sec/cm step to at least 12.5 sec/cm.

Magnifier: X10, overall accuracy $\pm 5\%$; expands 0.5 μ sec/cm speed to 50 nsec/cm.

Automatic triggering: (baseline displayed in the absence of an input signal).

Internal: 40 Hz to 500 kHz for signals causing 0.5 cm or more vertical deflection; also from line signal.

External: 40 Hz to 500 kHz for signals at least 0.5 V pk-pk.

Trigger slope: positive or negative slope of external sync signal or internal vertical deflection signal.

Amplitude selection triggering:

Internal: 10 Hz to 10 MHz for signals causing 0.5 cm or more vertical deflection.

External: for signals at least 0.5 V pk-pk; dc coupled, dc to 10 MHz; ac coupled, 10 Hz to 10 MHz; max. input, 600 V pk (dc + ac).

Trigger point and slope: from any point on the vertical waveform presented on crt; or continuously variable from -7 to $+7$ volts on external sync signal; positive or negative slope.

Single sweep: front panel switch permits single sweep operation.

Horizontal input:

Bandwidth: dc to better than 1.5 MHz (typically).

Deflection factor (sensitivity): vernier permits continuous adjustment from approx. 50 mV/cm to 5 V/cm.

Input RC: 1 megohm shunted by approx. 50 pF.

Weight: net 5 lbs (2.3 kg); shipping 7 lbs (3.2 kg).

Price: HP Model 1420A, \$325.

Range: 1 μ sec/cm to 5 sec/cm, 21 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends the 5 sec/cm step to at least 12.5 sec/cm.

Magnifier: X5, overall accuracy $\pm 5\%$; expands 1 μ sec/cm speed to 200 nsec/cm.

Automatic triggering: (baseline displayed in the absence of an input signal).

Internal: 50 Hz to 500 kHz for signals causing 0.5 cm or more vertical deflection; also from line signal.

External: 50 Hz to 500 kHz for signals at least 0.5 V pk-pk.

Trigger slope: positive or negative slope of external sync signal or internal vertical deflection signal.

Amplitude selection triggering:

Internal: dc or 10 Hz to 500 kHz (depending on vertical system) for signals causing 0.5 cm or more vertical deflection.

External: for signals at least 0.5 V pk-pk; dc coupled, dc to 500 kHz; ac coupled, 10 Hz to 500 kHz; max. input, 600 V pk (dc + ac).

Trigger point and slope: from any point on the vertical waveform presented on crt; or continuously variable from -10 to $+10$ volts on external sync signal; positive or negative slope.

Single sweep: front panel switch permits single sweep operation.

Horizontal input:

Bandwidth: dc coupled, dc to 400 kHz; ac coupled, 20 Hz to 400 kHz.

Deflection factor (sensitivity): vernier permits continuous adjustment from approx. 0.8 V/cm to 2.5 V/cm.

Input RC: 1 megohm shunted by approx. 150 pF.

Weight: net 5 lbs (2.3 kg); shipping 7 lbs (3.2 kg).

Price: HP Model 1422A, \$225.

Range: 0.2 μ sec/cm to 5 sec/cm, 23 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends the 5 sec/cm step to at least 12.5 sec/cm.

Magnifier: X10, overall accuracy $\pm 5\%$; expands 0.2 μ sec/cm speed to 20 nsec/cm.

Automatic triggering: (baseline displayed in the absence of an input signal) same as Normal, except lower limit is 40 Hz for both ac and dc coupling.

Normal triggering:

Internal: dc coupled: dc (with Models 1406A/1407A) to 15 MHz for signals causing 0.5 cm or more vertical deflection, to 20 MHz for 1 cm signals; ac coupled: 10 Hz to 15 MHz for 0.5 cm signals, to 20 MHz for 1 cm signals; ACF: approx. 2 kHz to 15 MHz for 0.5 cm signals, to 20 MHz for 1 cm signals.

External: for signals at least 0.5 V pk-pk; dc coupled, dc to 20 MHz; ac coupled, 10 Hz to 20 MHz; ACF, approx. 2 kHz to 20 MHz; max. input, 600 V pk (dc + ac).

Line: triggering from line frequency also selectable.

Trigger point and slope: selectable in both normal and automatic; from any point on the vertical waveform presented on crt, or continuously variable from -5 to $+5$ volts on external sync signal; positive or negative slope.

Trigger hold-off: time continuously variable, exceeding one full sweep at 50 msec/cm and faster, prevents multiple triggering on signals that have desired triggering level and slope appearing more than once per cycle.

Trigger input RC: dc and ac, approx. 1 megohm shunted by 50 pF; ACF, approx. 120 k ohms shunted by 50 pF.

Single sweep: front panel switch permits single sweep operation.

Horizontal input:

Bandwidth: dc to 500 kHz.

Deflection factor (sensitivity): vernier and X 10 magnifier permit continuous adjustment from approx. 300 mV/cm to 30 V/cm.

Input RC: 1 megohm shunted by approx. 50 pF.

Weight: net 5 lbs (2.3 kg); shipping 7 lbs (3.2 kg).

Price: HP Model 1423A, \$450.

TIME BASES

1421A TIME BASE AND DELAY GENERATOR

- Stable triggering to 20 MHz
- Single sweep in any mode
- Automatic triggering, easy to use
- Sweeps to 20 nsec/cm

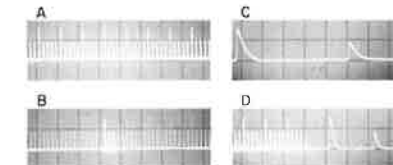


Description

The 1421A Time Base and Delay Generator provides sweep speeds to 20 nsec/cm with stable triggering to 20 MHz and beyond.

The delayed sweep feature of the 1421A permits detailed examination of any portion of a complex signal or pulse train by generating an accurately controlled delay time, at the end of which, a second sweep in the 1421A provides the deflection signal to the CRT. The 1421A has provision to trigger the deflection sweep at the end of the delay interval either automatically, on the vertical deflection signal (internal) or on an external signal. In the Automatic mode, the delayed sweep is immediately triggered at the end of the delay interval, thereby permitting accurate measurements of the time jitter in the input waveform. In the internal and external modes, the delayed sweep is armed at the end

of the delay interval and the signal triggers the delayed sweep. Thus the rise time and amplitude can be accurately measured without jitter.



The four basic sweep modes of the 1421A are shown above. (A) Normal Sweep; (B) Intensified Sweep, the deflection developed by the delaying sweep and the trace brightened during the time that the delayed sweep is running; (C) Delayed Sweep, the brightened portion of (B) expanded to full screen; and (D) Mixed Sweep, beam deflected initially by delaying sweep and then by the faster delayed sweep.

Specifications

Main sweep: for displaying signals vs time where sweep delay is not required; employs the main time base only.

Range: 0.2 μ sec/cm to 1 sec/cm, 21 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends 1 sec/cm step to at least 2.5 sec/cm.

Triggering: (when used with Model 1402A).

Amplitude selection

Internal: approx. 10 Hz to 15 MHz for signals causing 0.5 cm or more vertical deflection, to 20 MHz for 1 cm signals; also from line signal.

External: for signals at least 0.5 V pk-pk; dc coupled, dc to 20 MHz; ac coupled, approx. 5 Hz to 20 MHz.

Trigger point and slope: controls allow selection of level and positive or negative slope; trigger level of external sync signal is continuously variable from -5 to $+5$ volts.

Automatic: baseline displayed in the absence of an input signal; internally down to 40 Hz on signals causing 1 cm or more vertical deflection, also on line signal; externally down to 40 Hz on signals at least 1 V pk-pk; trigger slope, positive or negative.

Trace intensification: used for setting up Delayed or Mixed Sweep modes by increasing brightness of portion of Main Sweep which will be expanded to full screen in Delayed Sweep, or magnified portion of display in Mixed Sweep; rotating Delayed Sweep time switch out of Off position activates intensified mode.

Delayed sweep: delayed time base sweeps after a time delay set by Main Sweep and Delay Controls.

Range: 0.2 μ sec/cm to 50 msec/cm, 17 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$; vernier provides continuous adjustment between steps and extends 50 msec/cm step to at least 125 msec/cm.

Delay (before start of delayed sweep)

Time: continuously variable from 0.5 μ sec to 10 sec.

Accuracy: $\pm 1\%$; linearity, $\pm 0.2\%$; time jitter less than 0.005% of max. delay of each range (1 part in 20,000).

Trigger output: (at end of delay time) approx. +4 V with less than 150 nsec risetime, from 1 k ohms output impedance.

Triggering: (applies to intensified Main, Delayed, and Mixed Sweep modes).

Automatic: delayed sweep starts precisely at end of delay period.

Internal: delayed sweep triggered by vertical waveform presented on CRT after end of delay period; approx. 10 Hz to 15 MHz for signals causing 0.5 cm or more vertical deflection, or to 20 MHz for 1 cm signals.

External: delayed sweep triggered by external signal after end of delay period; for signals at least 0.5 V pk-pk; dc coupled, dc to 20 MHz; ac coupled, approx. 5 Hz to 20 MHz.

Trigger point and slope: (internal and external) Same as Main Sweep.

Mixed sweep: dual sweep-speed display in which main sweep drives first portion of display, and delayed sweep completes the display at sweep speeds up to 100 times faster; changeover point determined approx. by delay setting.

Triggering: same as for Delayed Sweep.

Magnifier: X 10, any display; overall accuracy $\pm 5\%$; expands 0.2 μ sec/cm speed to 20 nsec/cm.

Single sweep: any display can be operated in single sweep.

Horizontal input

Bandwidth: dc to typically better than 500 kHz.

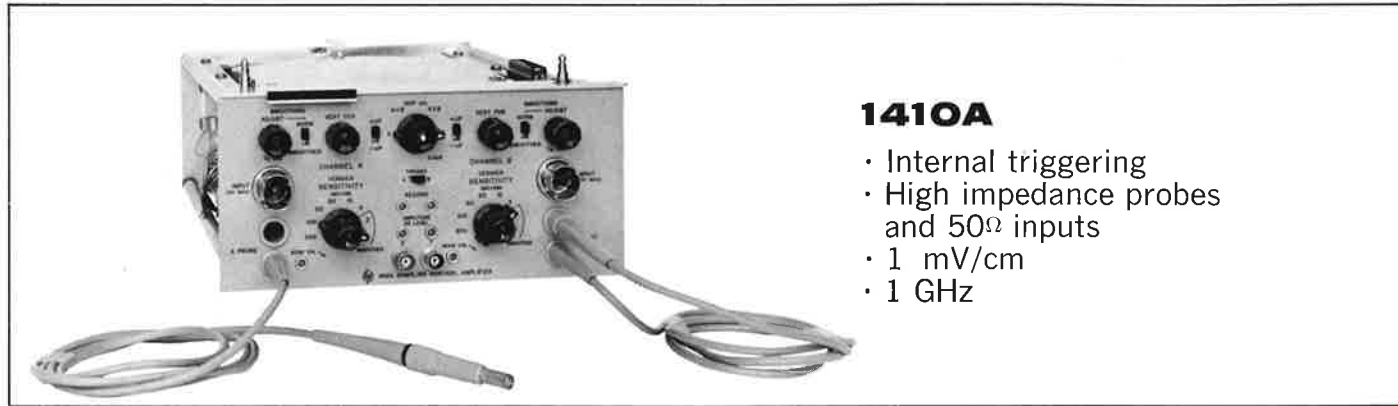
Deflection factor (sensitivity): vernier and X 10 magnifier permit continuous adjustment from approx. 0.3 V/cm to 30 V/cm.

Input RC: 1 megohm shunted by less than 20 pF.

Weight: net, 5 lbs (2.3 kg); shipping, 7 lbs (3.2 kg).

Price: HP Model 1421A, \$625.

1 GHz SAMPLING AMPLIFIER



1410A

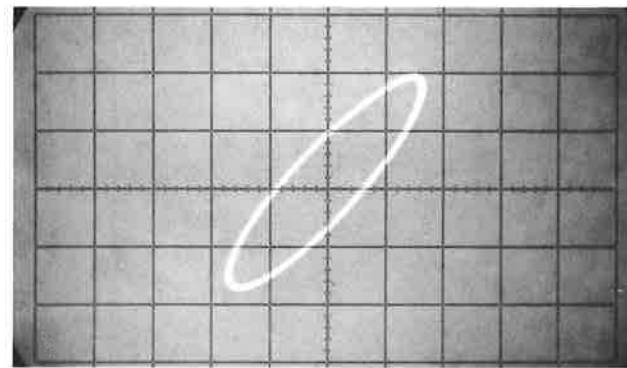
- Internal triggering
- High impedance probes and 50Ω inputs
- 1 mV/cm
- 1 GHz

Description

The Dual Channel 1410 A Sampling Vertical Amplifier provides 1 mV/cm sensitivity at 1GHz, and combines in a single instrument the convenience of high-impedance probes for circuit measurement PLUS 50-ohm inputs with delay lines for internal triggering—both with the full 1GHz bandwidth. Both give less than 100 psec time difference between channels for accurate phase measurements in the A vs B mode, and for precise dual trace time comparisons.

Optimum compromise among rise time, overshoot, and noise can be easily and quickly made with the front-panel rise time and smoothing controls.

Front-panel recorder outputs with both d-c level and amplitude adjustments simplify your X-Y or strip chart recorder setup and enable permanent recording of CRT traces.



The A vs. B mode of the 1410A permits X-Y measurements to 1 GHz and above.

Specifications

Mode of Operation:

1. Channel A only.
2. Channel B only.
3. Channel A and Channel B.
4. Channel A and Channel B added algebraically.
5. Channel A vs. Channel B.

Polarity: Either channel may be displayed either positive or negative up in any mode.

Rise Time: Less than 350 ps.

Bandwidth: DC to 1 GHz.

Overshoot: Less than 5%.

Sensitivity: Calibrated ranges from 1 mV/cm to 200 mV/cm in a 1, 2, 5 sequence. Vernier control provides continuous adjustment between ranges and increases maximum sensitivity to greater than 0.4 mV/cm.

Attenuator Accuracy: ±3%.

Isolation Between Channels: Greater than 40 dB to 1 GHz.

Input Impedance:

Probes: 100K ohms shunted by 2 pF nominal.

GR Type 874 Inputs: 50 ohms ±2% with 57 ns internal delay lines for viewing leading edge of fast rise signals. Reflection from input connector is approx. 10%, using a 150 ps TDR system.

Noise: (3 X rms, or observed signal excluding 10% of random dots, measured with probe terminated in 50Ω). Less than 1 mV, 5 mV/cm to 200 mV/cm. Noise decreases on automatically smoothed ranges 2 and 1 mV/cm. Smoothed position of smoothing switch reduces noise and jitter approximately 4:1. Vernier control provides continuous adjustment between the normal and smoothed modes.

Dynamic Range: ±2 volts.

Drift: Less than 3mV/hr after warmup.

Maximum Safe Input:

Probes: ±50 volts.

50Ω Inputs: ±5 volts

Triggering: Internal or external when using 50Ω inputs.

Internal triggering selectable from Channel A or B.

External triggering necessary when using probes.

Time Difference Between Channels (for probes or 50Ω inputs):

Less than 100 ps.

Recorder Outputs: Front panel outputs provide 0.1 V/cm from a 500Ω source. Gain adjustable from approximately 0.05 V/cm to 0.2 V/cm. DC level adjustable from approx. -1.5 V to +0.5 V.

Accessories Provided:

Model	Quantity	Description
10214A	2	10:1 Divider
10216A	2	Isolator
10217A	2	0.001 μF Blocking Capacitor
10218A	2	BNC Adapter
10219A	1	GR Adapter
10220A	2	Microdot Adapter
10221A	1	50Ω T-Connector
10213-62102	6	Ground Clip
5020-0457	6	Probe Tip
—	1	Accessory Box

Weight: Net, 10 lbs (4,5 kg). Shipping, 15 lbs (6,8 kg).

Price: \$1600.

1 GHz ACCESSORIES

1410A ACCESSORIES (Separately Available)



10214A 10:1 Divider. Permits accurate measurement of signals as large as 20 volts peak-to-peak and increases the impedance of the probe to 1 megohm shunted by 2.5 pF. Price, \$30.00.



10216A Isolator. Increases convenience and accuracy when probing by reducing base line shift and transient response changes caused by changes in the circuit source impedance. 1410A rise time is increased to approximately 0.6 nsec and probe input capacitance is increased by less than 3 pF. Price, \$25.00.



10217A Blocking Capacitor. This blocking capacitor (0.001 μF) permits measurements of signals that are ±50 volts from ground (to ±200 V when used with 10214A 10:1 Divider). The blocking capacitor contributes only 1% sag to a 1 μsec pulse when used with the probe alone, and 0.1% sag when used with the 10:1 divider. No more than 2.5 pF shunt capacitance is added to the input by the blocking capacitor. Price, \$20.00.



10218A BNC Adapter. Converts probe tip into a male BNC connector. Price, \$6.00.

10219A GR Adapter. Converts probe tip into a GR Type 874 connector. Price, \$11.00.

10220A Microdot Screw-on Adapter and 10223A Microdot Slide-on Adapter. Allows easy connection to coaxial connectors, and also provides a solid ground reference. Price: 10220A, \$3.50; 10223A, \$2.00.



10221A 50-ohm T Connector. Permits monitoring of signals in 50-ohm transmission lines with the 1410A without terminating the line or disturbing the signal. Mismatch is low; the reflection from a step input is no greater than 20% of the input step height. Price, \$40.00.

Additional Accessories (Not Supplied with 1410A)

10203A 100:1 Divider. This 100:1 divider may be used to reduce signal levels as high as 200 V to the ±2 V dynamic range of the 1410A. The 10203A offers less than 1 pf shunt capacity and 10 megohms shunt resistance to the circuit under test. (The K01-10203A Divider Adapter must be used to adapt the 10203A to the 1410A probe). Price, \$40.00.

K01-10203A Divider Adapter. Adapts the 10203A 100:1 Divider to the 1410A probe. Price, \$20.00.

1102B Accessory Kit

The Model 1102B Accessory Kit permits convenient circuit probing and reduced circuit loading with oscilloscopes that have 50-ohm input impedances. Thus it allows probing with the 1410A where the 50Ω inputs are used in order to get internal triggering. The kit is also ideal for the 1432A where a high input impedance is needed to prevent loading of the test circuit.

Specifications

10201A to D Resistive Divider Probes and 10122A Cable. The dividers should always be terminated with 50 ohms to provide the correct voltage division. They should not be attached directly to the 1410A probe.

Model	Input Resistance (ohms)*	Division Ratio	Division Ratio with 10205A Sync Take-Off	Max Input (vrms)†	μs for 1% Sag with 10209A
10201A	250	5:1	10:1	10	0.25
10201B	500	10:1	20:1	15	0.5
10201C	2500	50:1	100:1	35	2.5
10201D	5000	100:1	200:1	50	5.0

Input Capacitance: 0:4 pF.
Price, as sold separately, \$40.00 each.

* When terminated in 50 ohms.
† Limited by the power dissipation of the resistive element.

10208A Blocking Capacitor. This blocking capacitor (0.001 μf) permits measurements of signals that are ±600 volts from ground. No more than 0.5 pF shunt capacitance is added to the input by the blocking capacitor. Price, as sold separately, \$3.50.

10209A Blocking Capacitor. This blocking capacitor (0.1 μF) may be used to observe relatively long pulses or signals ±200 volts from ground. Signals which have rise times greater than 1 nsec may be displayed without distortion. No more than 3.5 pF shunt capacitance is added to the input. Price, as sold separately, \$27.00.

The kit also includes: 1 ea HP Model 10122A, Cable, Coaxial, Type N to BNC Female; 1 ea GR Type 874, Type N Female to GR Adapter; 2 ea HP Part Number 5060-0415, Ground Clip; and 1 ea Accessory Box.
Weight: Net, 3 lbs (1,4 kg). Shipping, 4 lbs (1,8 kg).
Price: Model 1102B Accessory Kit, \$160.00.

12.4 GHz SAMPLING AMPLIFIER



1411A

- Bandwidths to 12.4 GHz
- 1 mV/cm
- Remote samplers
- Feed-through inputs

Description

The 1411A Sampling Vertical Amplifier is a basic vertical plug-in that accepts a series of wide band samplers. All three samplers have 1 mV/cm sensitivity. Feed-through inputs are also featured, for monitoring signals without terminating them and for precise Time Domain Reflectometry measurements.

The remote samplers, connected to the oscilloscope by a five-foot cable, can be placed right at the signal

source, eliminating lossy lines.

Rise time is set with a front panel knob, allowing convenient adjustment of rise time and bandwidth to the ultimate when needed, at the sacrifice of increased noise. Front panel recorder outputs and an X-Y mode for wideband phase measurements add to the 1411A's measurement capability.

Specifications

(When used with 1430A, 1431A, or 1432A)

Mode of Operation:

1. Channel A only.
2. Channel B only.
3. Channel A and Channel B.
4. Channel A and Channel B added algebraically.
5. Channel A vs. Channel B.

Polarity: Either channel may be displayed either positive or negative up in any mode.

Sensitivity: Calibrated ranges from 1 mV/cm to 200 mV/cm in a 1, 2, 5 sequence. Vernier control provides

continuous adjustment between ranges and increases maximum sensitivity to greater than 0.4 mV/cm.

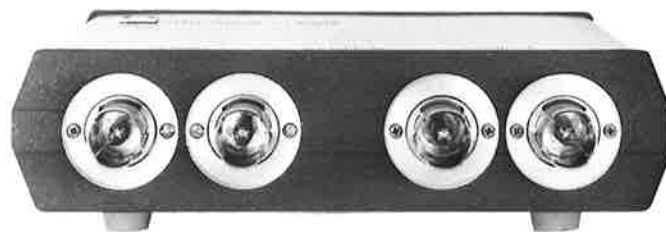
Attenuator Accuracy: $\pm 3\%$.

Isolation Between Channels: Greater than 40 dB over bandwidth of sampler.

Recorder Outputs: Front panel outputs provide 0.1 V/cm from a 500 Ω source. Gain adjustable from approx. 0.05 V/cm to 0.2 V/cm. DC level adjustable from approx. -1.5 V to +0.5 V.

Weight: Net, 10 lbs (4.5 kg). Shipping, 15 lbs (6.8 kg).
Price: \$700.

1432A 90 psec SAMPLER



The 1432A is a lower-priced version of the 1430A and 1431A. Its 90 psec rise time (DC to 4 GHz bandwidth), 1 mV/cm sensitivity, and feed through inputs permit many accurate measurements involving CW, fast pulses, and TDR.

Specifications

(When used with 1411A)

Rise Time: Less than 90 ps.

Bandwidth: DC to 4 GHz.

Overshoot: Less than $\pm 5\%$.

Noise: Less than 3 mV from 5 mV/cm to 200 mV/cm (otherwise same as 1430A).

Dynamic Range: ± 1 volt.

Low Frequency Distortion: Less than $\pm 3\%$.

Maximum Safe Input: ± 5 volts.

Input Characteristics:

Mechanical: GR type 874 connectors used on input and output.

Electrical: 50 ohm feedthrough, dc coupled. Reflection from sampler is approx. 15% using a 90 ps TDR system. Pulses emitted from sampler input are approximately 50 mV in amplitude and 10 ns wide.

Time Difference Between Channels: Less than 25 psec.

Connecting Cable Length: 5 ft. (for longer cable, see special order below).

Weight: Net, 4 lbs (1.8 kg). Shipping, 9 lbs (4.1 kg).

Accessories Provided: Two GR Model 874-W50 50 ohm loads.

Price: \$1000

Special Order: 10-ft. connecting cable (5-ft. is standard), order C01-1432A. Price, \$1035.

12.4 GHz SAMPLERS

1430A 28 psec SAMPLER

1431A 12.4 GHz SAMPLER



Description

The 1430A provides 28 psec rise time with minimal overshoot for accurate measurements on fast-rise pulses. Used with the 1105A/1106A 20 psec pulse generator, its response and feed-through inputs make it ideal for TDR measurements

The 1431A allows viewing of CW signals from dc to beyond 12.4 GHz at 1 mV/cm sensitivity. It differs slightly from the 1430A, having a very flat bandwidth and low VSWR at the sacrifice of increased overshoot.

Specifications

1430A

(When used with 1411A)

Rise Time: Approx. 28 ps. (Less than 35 ps observed with 1105A/1106A pulse generator and 909A 50-ohm load.)

Bandwidth: DC to approx. 12.4 GHz.

Overshoot: Less than $\pm 5\%$.

Noise: (3 X rms, or observed signal excluding 10% of random dots.) Less than 8 mV, 5 mV/cm to 200 mV/cm. Noise decreases on automatically smoothed ranges 5, 2, and 1 mV/cm. Smoothed position of smoothing switch reduces noise and jitter approximately 4:1. Vernier control provides continuous adjustment between the normal and smoothed modes.

Dynamic Range: ± 1 volt.

Low Frequency Distortion: Less than $\pm 3\%$.

Maximum Safe Input: ± 3 volts.

Input Characteristics:

Mechanical: Amphenol APC-7 precision 7 mm connectors on input and output.

Electrical: 50 ohm feedthrough, dc coupled. Reflection from sampler is approx. 10%, using a 40 ps TDR system. Pulses emitted from sampler input are approximately 10 mV in amplitude and 5 ns in duration. VSWR $< 3:1$ at 12.4 GHz.

Time Difference Between Channels: Less than 5 ps.

Connecting Cable Length: 5 ft. (for longer cable see special order below).

Weight: Net, 4 lbs (1.8 kg). Shipping 9 lbs (4.1 kg).

Accessories Provided: Two Amphenol APC-7 to female Type N adapters (HP 10224A). Two 50-ohm loads (HP 909A).

Price: \$3000.

Special Order: 10-ft. connecting cable (5-ft. is standard), order C01-1430A. Price, \$3035.

1431A

(When used with 1411A)

Bandwidth: DC to greater than 12.4 GHz (less than 3 dB down from a 10 cm dc reference).

Rise Time: Approx. 28 psec.

VSWR: DC to 8 GHz 1.4:1
8 to 10 GHz 1.6:1
10 to 12.4 GHz 2.0:1

Noise: Less than 7 mV from 5 mV/cm to 200 mV/cm (otherwise same as 1430A).

Dynamic Range: ± 1 volt.

Low Frequency Distortion: Less than $\pm 3\%$.

Maximum Safe Input: ± 3 volts.

Input Characteristics:

Mechanical: Amphenol APC-7 precision 7 mm connector used on input and output.

Electrical: 50-ohm feedthrough, dc coupled. Reflection from sampler is approx. 5%, using a 40 ps TDR system. Pulses emitted from sampler input are approximately 10 mV in amplitude and 5 ns in duration.

Phase Shift Between Channels: Less than 10° at 5 GHz, typically less than 2° at 1 GHz.

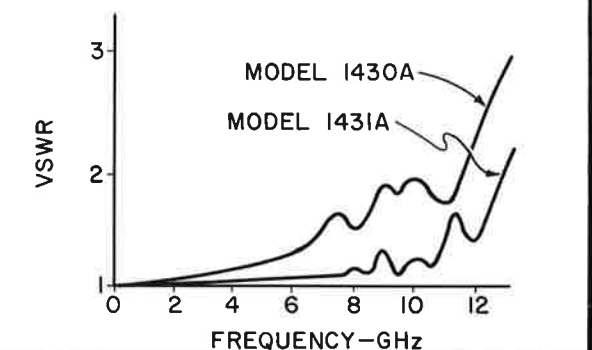
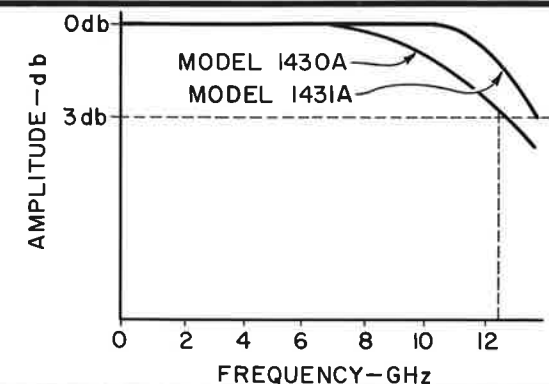
Connecting Cable Length: 5 ft. (for longer cable see special order below).

Weight: Net, 4 lbs (1.8 kg). Shipping 9 lbs (4.1 kg).

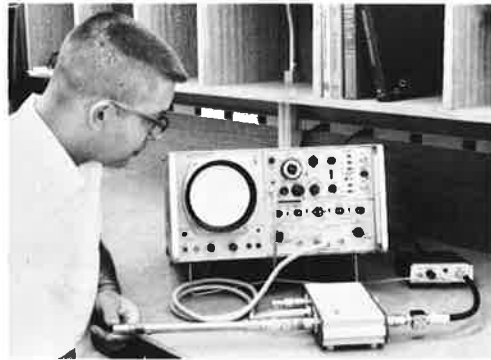
Accessories Provided: Two Amphenol APC-7 to female Type N adapters (HP 10224A). Two 50-ohm loads (HP 909A).

Price: \$3000.

Special Order: 10-ft. connecting cable (5-ft. is standard), order C01-1431A. Price, \$3035.



12.4 GHz SAMPLING APPLICATIONS



- 40 psec TDR
- Discontinuity Resolution to less than 1 cm
- Remote Sampling Heads
- Reflection coefficient sensitivity to .002/cm

Description

If design of GHz coaxial components is important to you then HP's new sampling system used as a Time Domain Reflectometer is your answer. For the first time you can see discontinuities causing undesired reflections at very high frequencies. Connectors, attenuators, delay lines, distributed deflection plates, switches, and strip lines are just a few of the many devices that can be designed or checked quickly because of this new advance in sampling techniques.

HP Models 1424A or 1425A Time Base, 1411A

Vertical Amplifier, 1430A 28 psec Sampler, and the 1105/1106A Fast Rise Pulser make up the system. 20 psec pulses (with less than 5% overshoot) driven through the 28 psec sampler into the system under test form a TDR system with a rise time of less than 40 psec which is about the time it takes light to travel $\frac{1}{2}$ " in air.

Contact your HP Field Engineer soon for a demo on your own application. It may be the solution to one or more of your unanswered design problems.

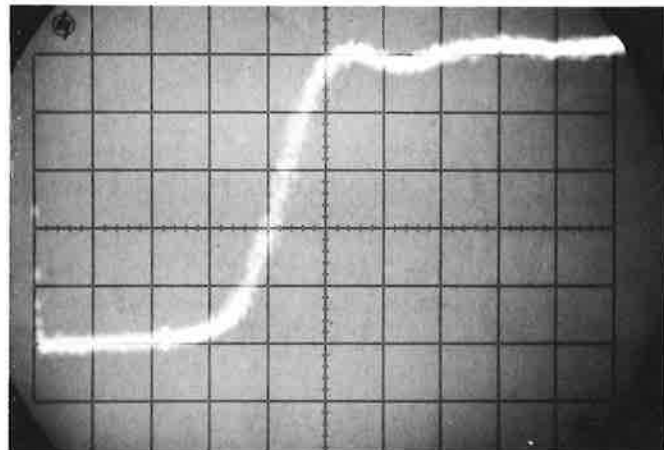


Fig. 1. Response of sampler to incident step in TDR System of Fig. 3. Typical rise time is less than 35 ps. Vertical: reflection coefficient = 0.2/cm; Horizontal: 20ps/cm.

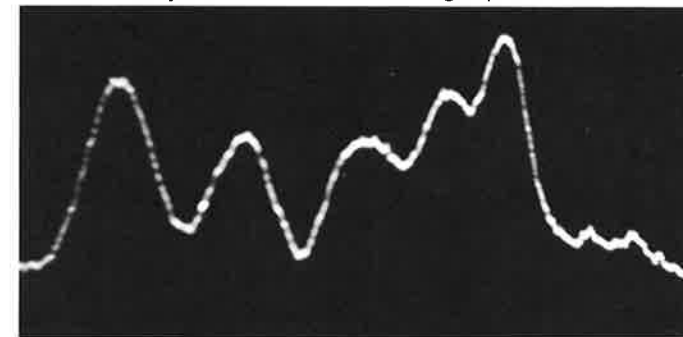


Fig. 2. Typical TDR resolution of discontinuities in a cable-conductor-adaptor-conductor-cable combination. a) large cable connected to connector; b) connector to adapter; c) 50Ω bead in adapter; d) adapter to connector; and e) connector to small cable. Horizontal: 50 psec/cm; Vertical: reflection coefficient = .004/cm.

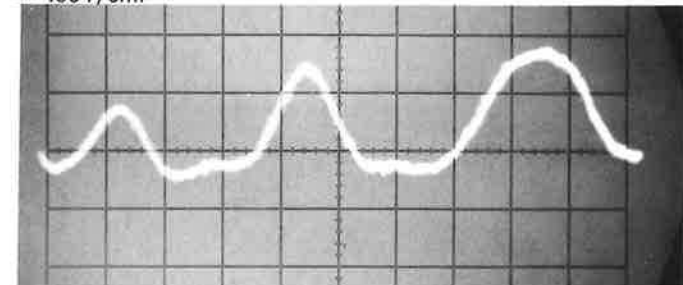
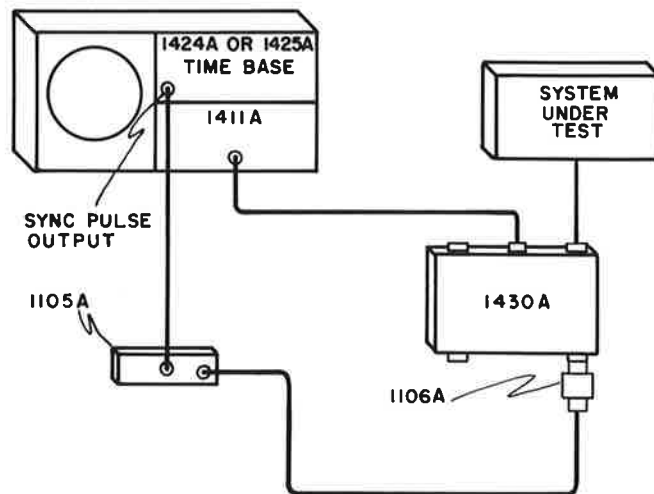


Fig. 3. Reflections were caused by three sections of 75Ω center conductors inserted into a 50Ω air line. They are $\frac{1}{8}$ ", $\frac{1}{4}$ " and $\frac{1}{2}$ " in length spaced by $\frac{5}{8}$ ". The $\frac{1}{2}$ " section has reached maximum deflection (flattened slightly) and even the $\frac{1}{4}$ " section is very near the same magnitude.



12.4 GHz SAMPLING APPLICATIONS



- 12.4 GHz
- Low VSWR
- 18 GHz Trigger Countdown

Description

Whether your application is in the design or monitoring of microwave systems, you can, for the first time make accurate oscilloscope measurements through X-band.

Observe outputs from your signal source for amplitude, distortion and jitter. Check gain, distortion, frequency and phase shift of TWT and other high frequency amplifiers. All types of modulated signals can be looked at for modulation index, distortion, and

phase shift. Low frequency distortion can be detected by making X-Y recordings using the recorder outputs of the Vertical Amplifier.

All this and more is made possible using the HP 1431A 12.4 GHz Sampler with the HP 1411A Vertical Amplifier, the HP 1424A or 1425A Time Base, and the HP 1104A/1106A Trigger Countdown. Select the HP 140A Main Frame or, if you prefer, the HP 141A Variable Persistence and Storage Main Frame.

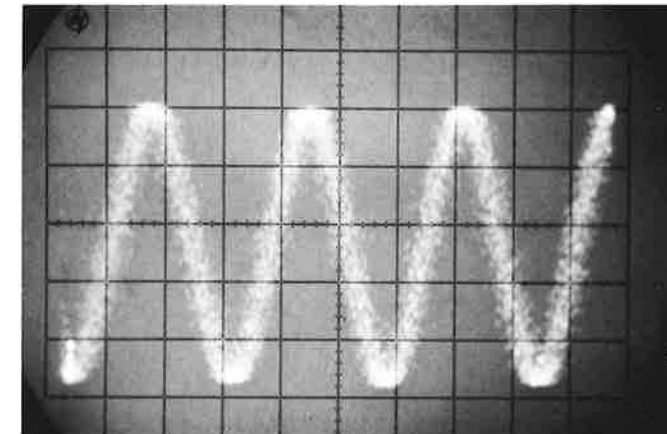


Figure 1. Oscilloscope shows 18 GHz sine wave. Note that jitter even at this frequency is less than 10 psec. Signal was obtained using 1431A 12.4 GHz Sampler and 1104A/1105A Trigger Countdown.

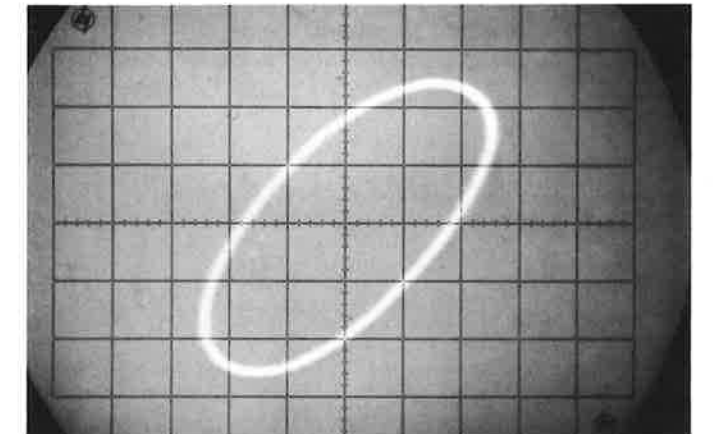


Figure 3. Accurate phase measurements can be made with the HP Model 1431A 12.4 GHz Sampler which has less than 10° phase difference between channels at 5GHz and typically less than 2° at 1GHz.

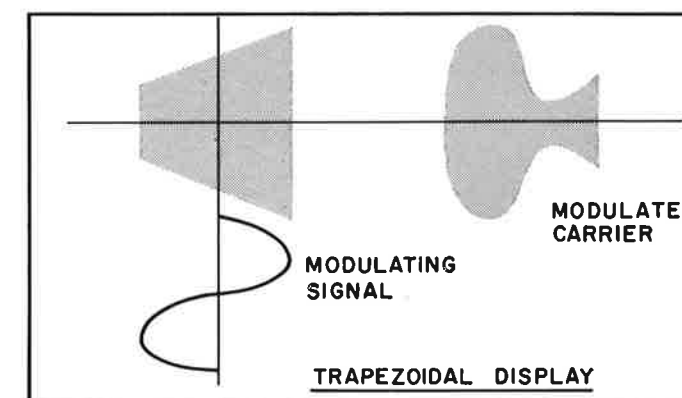


Figure 2. Displays like this one represent a technique of measuring characteristics of a modulator without the need for triggering. Basically, the idea is to feed the modulated carrier into the vertical channel and the modulating signal into the horizontal channel. Set MODE to A Vs B and free run the sweep.

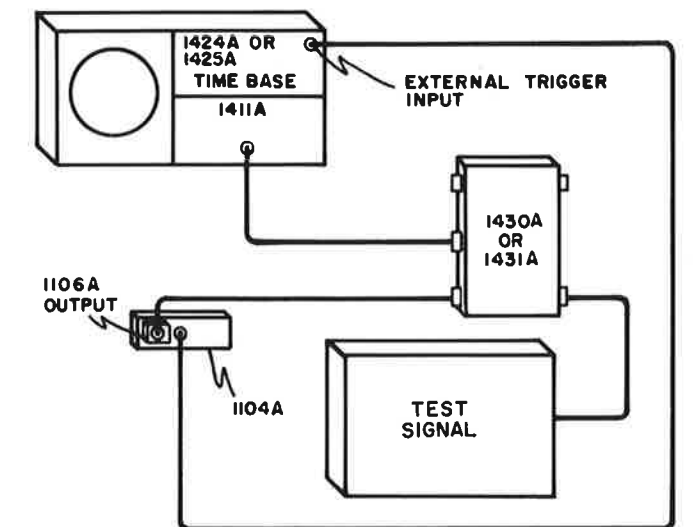


Figure 4. This is a typical hookup of HP's new Sampling systems for measuring or monitoring microwave signals.

SAMPLING TIME BASES



1424A

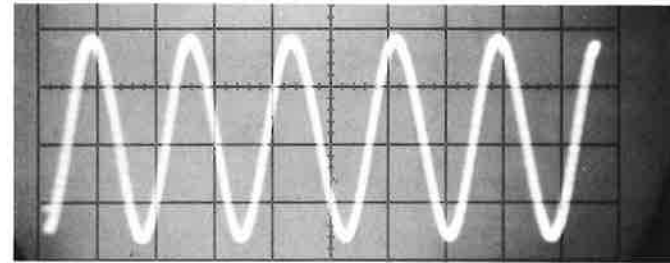
- Direct readout of all sweeps
- Calibrated sweeps to 10 psec/cm
- Triggering to 5 GHz

Description

The 1424A is an easy-to-operate time base for use with the 1410A and 1411A plug-ins. Convenient and more meaningful measurements are made possible through features such as: calibrated sweeps as fast as 10 psec/cm, low jitter, triggering to 5GHz, and direct readout of sweeps, even when expanded. Accurate time interval measurements can be made with the calibrated marker position control which positions the intensified marker to the point on the trace about which expansion is desired.

A baseline in the absence of an input signal is provided with automatic triggering which locks in on a wide range of signals. A single scan feature helps provide clearer photos and stored traces of drifting or changing signals. The external scan input makes the 1424A adaptable to automatic systems, and allows

the use of a strip chart recorder rather than a more expensive X-Y recorder.



Solid triggering to 5 GHz without external count down box.

Specifications

Sweep Range: 24 ranges, 10 ps/cm to 500 μ s/cm in a 1, 2, 5 sequence. Sweeps from 1 ns/cm to 500 μ s/cm may be expanded up to 100 times and read out directly. Sweeps from 10 ps/cm to 500 ps/cm are obtained by expansion and also read out directly. Accuracy $\pm 3\%$ except for slight non-linearity at start of normal (unexpanded) sweep. Vernier provides continuous adjustment between ranges and increases maximum sweep speed to faster than 4 ps/cm.

Marker Position: Intensified marker indicates point about which sweep is expanded; 10-turn, calibrated control.

Minimum Delay: Less than 55 ns.

Triggering: (Less than 1 GHz)

Internal (with 1410A):

Automatic: Baseline displayed in the absence of an input signal.

Pulses: At least 40 mV amplitude required of pulses 2 ns or wider for jitter less than 30 ps.

Sine Waves: Signals from 200 Hz to 300 MHz require 25 mV amplitude for jitter less than 10% of input signal period. (Usable to 1 GHz with increased jitter.)

Level Select:

Pulses: At least 50 mV amplitude required for pulses 2 ns or wider for jitter less than 20 ps.

Sine Waves: Signals require from 200 Hz to 300 MHz 25 mV amplitude (increasing to 200 mV at 1 GHz) for jitter less than 1.5% of input signal period + 10 psec.

External:

Automatic: Baseline displayed in the absence of an input signal.

Pulses: At least 100 mV amplitude required of fast rise pulses 2 ns or wider for jitter less than 20 ps.

Sine Waves: Signals from 200 Hz to 500 MHz require 50 mV for jitter less than 10% of input signal period. (Usable to 1 GHz with increased jitter.)

Level Select:

Pulses: At least 50 mV amplitude required of fast rise pulses 2 ns or wider for jitter less than 20 ps.

Sine Waves: Signals from 200 Hz to 1 GHz require 50 mV for jitter less than 1.5% of input signal period + 10 psec. Jitter is less than 50 ps for signals of 10 mV at 1 GHz.

Slope: Positive or negative.

Sensitivity: Jitter specifications above given for sensitive mode; normal mode reduces sensitivity by approximately 10:1.

Dynamic Range: 100 mV in sensitive 1.0 V in normal (external).

External Trigger Input: 50 Ω , ac or dc coupled; signal output, <10 mV in sensitive and <5 mV in normal.

Maximum Safe Input: Sensitive, 5 V rms or peak transient. Normal, 5 V rms (50 V peak transient). Internal, 5 V rms or peak transient.

Jitter: Less than 10 ps on 1 ns/cm range, and less than 20 ps (or 0.005% of unexpanded sweep speed, whichever is larger) at 2 ns/cm and slower, with signals having rise times of 1 ns or faster.

Triggering: (Greater than 1 GHz)

Jitter less than 20 ps for 25 mV input, 500 MHz to 5 GHz.

Scanning:

Internal: X axis driven from internal source. Scan density continuously variable.

Manual: X axis driven by manual scan control knob.

Record: X axis driven by internal slow ramp; approximately 60 seconds for one scan.

External: 0 to +15 V required for scan; input impedance, 10k Ω .

Single Scan: One scan per actuation; scan density continuously variable.

Sync Pulse Output:

Amplitude: Greater than 1.5 V into 50 Ω .

Rise Time: Approx. 1 ns.

Overshoot: Less than 5%.

Width: Approximately 1 μ sec.

Relative Jitter: Less than 10 ps.

Repetition Rate: One pulse per sample.

Weight: Net, 5lbs (2,3 kg). Shipping, 9 lbs (4,1 kg).

Price: \$1200.

SAMPLING TIME BASES



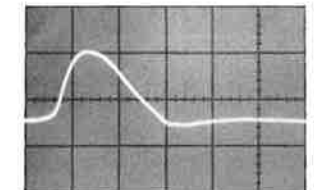
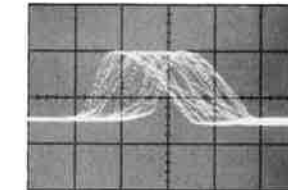
1425A

- Delayed sweep
- Calibrated sweeps to 10 ps/cm
- Triggering to 1 GHz

Description

The 1425's delayed sweep feature allows detailed examination (magnification as great as 10,000:1) of any portion of complex signals and pulse trains for the first time in the GHz region. And accurate time jitter measurements in the input waveform can be measured when in the Automatic triggering mode. This same automatic triggering mode provides a baseline in the absence of an input signal aiding in getting a trace displayed sooner.

When you want to set up a magnified trace, an intensified marker dot locates the expansion point for you. You also get push-button return to X1 magnification for fast reference or relocation of the expansion point.



Jitter on delayed pulse in left photo eliminated at right by triggering the delayed sweep. Sweep speed, 1 ns/cm; delay, 5 μ sec.

Specifications

Main Sweep:

Range: 1 nsec/cm to 10 μ sec/cm, 13 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$, except for slight non-linearity at start of unexpanded sweep; vernier provides continuous adjustment between steps and extends maximum magnified speed to at least 4 psec/cm.

Magnifier: X1 to X100 in 7 calibrated steps; increase 1 nsec/cm sweep step to 10 psec/cm; push button returns magnifier to X1.

Marker Position: Intensified marker indicates point about which sweep is expanded; 10-turn control.

Minimum Delay: Main Sweep, less than 55 nsec; Main Delayed Sweep, less than 105 nsec.

Triggering: (for both Main and Delaying Sweep)

Internal:

Automatic: Baseline displayed in the absence of an input signal.

Pulses: At least 75 mV amplitude required of pulses 2 nsec or wider for jitter less than 30 psec.

Sine Waves: Signals from 200 Hz to 300 MHz require 50 mV amplitude for jitter less than 10% of input signal period (usable to 1 GHz with increased jitter).

Level Select:

Pulses: At least 100 mV amplitude required of fast rise pulses 2 nsec or wider for jitter less than 20 psec.

Sine Waves: Signals from 200 Hz to 300 MHz require 50 mV amplitude (increasing to 400 mV at 1 GHz) for jitter less than 1.5% of input signal period + 10 psec.

External:

Automatic: Baseline displayed in the absence of an input signal.

Pulses: At least 100 mV amplitude required of fast rise pulses 2 nsec or wider for jitter less than 20 psec.

Sine Waves: Signals from 200 Hz to 500 MHz require 50 mV amplitude for jitter less than 10% of input signal period (usable to 1 GHz with increased jitter).

Level Select:

Pulses: At least 50 mV amplitude required for fast rise pulses 2 nsec or wider for jitter less than 20 psec.

Sine Waves: Signals from 200 Hz to 1 GHz require 50 mV for jitter less than 1.5% of input signal period + 10 psec; jitter is less than 50 psec for signals of 10 mV amplitude at 1 GHz.

External Trigger Input: 50-ohms, ac-coupled (2.2 μ F); signal output, less than 10 mV in sensitive, and less than 5 mV in normal.

Slope: Positive or negative.

Sensitivity: Jitter specifications given above are for sensitive mode; normal mode reduces sensitivity by approx. 10:1.

Dynamic Range: 100 mV in sensitive, 1.0 V in normal (external).

Maximum Input: Sensitive, 5 V rms or peak transient; normal 5 V rms (50 V pk transient); internal, 5 V rms or peak transient.

Jitter: Less than 10 psec on 1 nsec/cm range and less than 20 psec (or 0.005% of unexpanded sweep, whichever is larger) at 2 nsec/cm and slower, with large amplitude signals having rise times of 1 nsec or faster.

Delaying Sweep:

Range: 10 nsec/cm to 500 μ sec/cm, 15 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$, except for slight nonlinearity at start of sweep, $\pm 5\%$ on 200 μ s/cm and 500 μ s/cm ranges, vernier provides continuous adjustment between steps and increases 10 nsec/cm step to at least 4 nsec/cm.

Delay Time: Continuously variable from 50 nsec to 5 msec.

Accuracy: $\pm 3\%$; linearity 0.5%; jitter time is less than 1 part in 20,000 or 20 psec, whichever is greater.

Sweep Functions: Main, delaying, and main delayed.

Scanning: Same as 1424A except no external scan input.

Sync Pulse Output: Same as 1424A. Pulse always synchronized to main sweep trigger circuit; pulse delay and rate are variable.

Weight: Net, 7 lbs (3,2 kg). Shipping, 11 lbs (5 kg).

Price: \$1600.

SAMPLING ACCESSORIES

1105A/1106A 20 psec Pulse Generator



Specifications

Output:

Rise Time: Approximately 20 ps. Less than 35 ps observed with HP Model 1411A/1430A 28 psec Sampler and HP Model 909A 50 ohm termination.
Overshoot: Less than $\pm 5\%$ as observed on 1411A/1430A with 909A.
Droop: Less than 3% in first 100 ns.
Width: Approximately 3 μ s.
Amplitude: Greater than +200 mV into 50 Ω .
Output Characteristics (1106A):
Mechanical: Amphenol APC-7 connector.
Electrical: DC resistance—50 $\Omega \pm 2\%$. Source reflection—less than 10%, using a 40 ps TDR system. DC offset voltage—approximately 0.1 V.

Triggering:

Amplitude: At least ± 0.5 V peak required.
Rise Time: Less than 20 ns required. Jitter less than 15 ps when triggered by 1 ns rise time sync pulse from 1424A or 1425A Sampling Time Base.
Width: Greater than 2 ns.
Maximum Safe Input: 10 volts.
Input Impedance: 200 ohms, ac coupled through 20 pF.
Repetition Rate: 0 to 100 kHz; free runs at 100 kHz.

Accessories Provided (with Model 1105A):

One 6-ft. 50 Ω cable with male Type N connectors, HP Model No. 10132A.

Weight:

1105A: Net, 3 lbs (1,4 kg). Shipping, 8 lbs (3,6 kg).
1106A: Net 1 lb (0,5 kg). Shipping, 3 lbs (1,4 kg).
Price: 1105A, \$200. 1106A, \$550.

Model 213B Pulse Generator



Combines fast rise time (100 psec) with low jitter and 100 kc repetition rate. The pulse has minimum overshoot and is flat for 100 nsec after the fast rise. It contains useful harmonics from 10 MHz to 3.5 GHz. Price, \$215.

COAXIAL ATTENUATORS

8492A Fixed Coaxial Attenuator*

Nominal attenuation: Options 03, 3 dB; 06, 6 dB; 10, 10 dB; 20, 20 dB. APC-7 connectors. Range dc to 18 GHz.

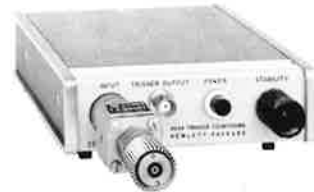
Price: \$125.

8491A Fixed Coaxial Attenuator*

Nominal attenuation: Options 03, 3 dB; 06, 6 dB; 10, 10 dB; 20, 20 dB. Type N connectors, 1 male, 1 female. Range dc to 12.4 GHz.

Price: \$50.

1104A/1106A 18 GHz Trigger Countdown



Specifications

Input:

Frequency Range: 1 GHz to 18 GHz.
Sensitivity: Signals 100 mV or larger, and up to 12.4 GHz, produce less than 20 ps of jitter (200 mV required to 18 GHz).
Maximum Safe Input: ± 25 ma.
Input Impedance (1106A): 50-ohm Amphenol APC-7 input connector. Reflection from input connector is less than 10%, using a 40 ps TDR system.
Signal Appearing at Input Connector: Less than 250 mVstep whose top is flat within 2% for 1 ns.

Output:

Center Frequency: Approximately 150 MHz.
Amplitude: Typically 100 mV.

Weight:

1104A: Net, 2 lbs (0,9 kg). Shipping, 4 lbs (1,8 kg).
1106A: Net, 1 lb (0,5 kg). Shipping, 3 lbs (1,4 kg).
Price: 1104A, \$200. 1106A, \$550.

Model 1103A Trigger Countdown



Permits stable triggering, 500 MHz to 10 GHz, by dividing down input trigger frequency to about 30 MHz. 15 mV rms input produces less than 30 psec jitter at 5 GHz. Sensitivity decreases above 5 GHz to about 250 mv at 10 GHz. Price, \$265.

50-OHM LOADS

The hp 908A and 909A are 50-ohm terminating coaxial loads with frequency ranges of dc-4 GHz and dc-18 GHz respectively. The 908A has a Type N male connector and the 909A has an APC-7 with Type N option. Price: 908A, \$35; 909A, \$75.

Model 10200B Sync Probe

The 10200B, for use with Model 1424A and 1425A Sampling Time Bases, increases trigger input impedance to more than 750 ohms, ac coupled. It reduces sensitivity by about 4:1 at 10 MHz and higher, and by about 20:1 at low frequencies. Price, \$50.

50-OHM ADAPTER

The Model 10224A type N to APC-7 Adapter has a frequency range of 18 GHz. This adapter uses hp's new stainless steel precision type N female connector. Price, \$75.

AIR LINE EXTENSIONS

Price: 11566A 10 cm / 11567A 20 cm air line extensions, \$100.

SWEPT FREQUENCY INDICATOR



1416A

- Speeds and simplifies swept-frequency measurements
- High resolution readout directly in dB
- Low drift
- X-Y recorder outputs

Description

The Model 1416A Swept Frequency Indicator transforms the Model 140A/141A into an X-Y oscilloscope which speeds and simplifies microwave swept-frequency measurements. Insertion loss vs. frequency measurements on attenuators, filters, ferrite isolators, and return loss measurements on all types of loads can be made with ease and accuracy.

The Model 1416A incorporates a number of features which provide convenience and accuracy not available with the usually used conventional X-Y scope. Readouts directly in dB are provided by the Model 1416A's logarithmic amplifier. The Attenuation-dB control allows a calibrated dB offset to be applied to an offscreen trace, allowing it to be centered on screen and for high resolution readings. A linear mode of operation is also provided. A chopper stabilized input amplifier minimizes drift, and a front-panel adjustable bandwidth switch allows the operator to select a bandwidth just wide enough to present the signal with a minimum

amount of noise. An internal dB calibrator, accurate to 3%, allows a quick check of amplifier accuracy. Also provided on the front panel are outputs for driving an X-Y recorder. Thus, you can now achieve speed, convenience, and accuracy with all types of swept-frequency measurements by using the Model 140A-141A/1416A combination and appropriate auxiliary equipment. Sweep oscillators and associated instruments are available for testing both coaxial and waveguide microwave components from 1 to 40 GHz. Such items as adapters, impedance transformers, tuners, loads, filters, detectors, couplers, and attenuators can be measured or adjusted. Swept-frequency techniques are also useful for over-all system analysis.

Swept-frequency techniques are not only helpful design aids, but can be used as maintenance tools as well. They provide fast routine maintenance checks on laboratory instruments. Hours, and sometimes days, of tedious precise measurements can often be completed within minutes.

Specifications

Mode of operation: linear or logarithmic.

Bandwidth:

Linear: variable from approximately 1 kHz to 30 kHz in four steps.

Logarithmic: varies with input level.

Deflection factor (sensitivity):

Linear: 50 μ V/cm to 10 mV/cm, 8 ranges in a 1, 2, 5 sequence; accuracy $\pm 3\%$.

Logarithmic: 0.5 dB/cm to 10 dB/cm (referred to rf input into crystal detector) in 5 ranges; accuracy (after 30-min. warmup), ± 0.02 dB/dB (0 to -25 dB) and ± 0.03 dB/dB (-25 to -30 dB).

Noise: typical observed values on CRT:

Mode	Noise at low bandwidth	Noise at high bandwidth
Linear	40 μ V pk-pk	200 μ V pk-pk
Logarithmic:		
input signal level		
0 dB	0.05 dB	0.1 dB
-10 dB	0.05 dB	0.2 dB
-20 dB	0.3 dB	0.4 dB
-25 dB	1 dB	1 dB
-30 dB	4 dB	4 dB

Maximum measured noise at RECORDER OUTPUT: (measured with a True RMS Voltmeter, and recorder output deflection factor set to 200 mV/cm).

Linear: less than 120 mV; Model 1416A deflection factor set to 0.05 mV/cm and input shortened.

Logarithmic: less than 50 mV/cm; Model 1416A deflection factor set to 5 dB/cm and input signal of -50 μ V (-30 dB).

Internal calibrator: four positions: 0, 10, 20, and 30 dB below approximately 50 mV; accuracy ± 0.01 dB/dB.

Sweep and blanking: supplied by Model 690-Series Sweep Oscillator.

Recorder outputs:
Vertical: gain adjustable from 0 to approximately 200 mV/cm; dc level adjustable over approximately ± 1.5 volts.

Horizontal: gain adjustable from 0 to approximately 100 mV/cm; dc level adjustable over approximately ± 1 volt.

Inputs:
Vertical: input impedance, 75 k ohms; dynamic range: logarithmic, -50 μ V to -100 mV; linear 0 to -100 mV; BNC connector receives output from Models 423A or 424A Crystal Detectors, or Models 786D or 787D Directional Detectors (all Option 02).

Horizontal: ramp required: amplitude between 7.5 and 20 volts; some part of ramp must be at 0 volts.

Blanking: 0 to -5 V gate (supplied by Model 690-Series Sweep Oscillator; early models require slight modification).

Power: supplied by oscilloscope.
Weight: net 7 lbs (3,2 kg); shipping 14 lbs (6,3 kg).
Price: HP Model 1416A, \$675.

TIME DOMAIN REFLECTOMETER



1415A

- Complete system for testing cables, connectors, striplines
- Determines location, magnitude, and nature of each discontinuity
- Locates discontinuities within an inch
- Easy to operate

Description

The 1415A Time Domain Reflectometer/140A or 141A Oscilloscope represents a completely integrated broadband system for testing cables, transmission lines, strip lines, connectors and many other types of devices used in your high frequency systems.

You can, for example, quickly determine the magnitude and nature of each resistive or reactive discontinuity in coaxial components such as attenuators, cables, connectors and delay lines used in microwave and pulse circuit design. Or you can locate and identify cable faults such as shorts, opens, loose connectors, defective tap offs, splices and mismatches if you are using cables for signal transmission. Whatever your application the 1415A can save you time and money by minimizing guesswork and indecision.

The 1415A is a completely self-contained system consisting of a fast rise pulse generator, single channel sampler, and time base. No additional vertical or horizontal amplifiers are required, eliminating introduction of additional chances of error. The compact control panel contains only those controls necessary for TDR measurements—making the 1415A much simpler to operate than comparable systems costing twice as much.



Magnified display of a BNC connector joining two 50-ohm cables. The horizontal axis is set at 2 cm/cm. Multiplying the 3.5 cm deflection by the reflection coefficient sensitivity of 0.01/cm, one can determine the connector has a ρ of 0.035.



TDR display of a section of unknown cable spliced into a length of 50-ohm cable. Noting the distance setting of 40 cm/cm, and reflection coefficient sensitivity of 0.2/cm, one can determine the unknown cable is 120 cm long and has a Z_0 of 44 ohms.

Specifications

System (in reflectometer configuration):

- Rise Time: Less than 150 psec.
- Overshoot: 5% or less overshoot and ringing (down to $1/2\%$ in 2 nsec).
- Internal Reflections: Less than 10% (does not limit resolution).
- Reflectometer Sensitivity: Reflection coefficients as small as 0.001 can be observed.
- Rep. Rate: 150 kc nominal.

Signal Channel:

- Rise time: Approximately 110 psec.
- Reflection Coefficient: 0.5/cm to 0.005/cm in 1, 2, 5 sequence.
- Input: 50 ohms, feed-through type.
- Noise and Internal Pickup, Peak: 0.1% of step (terminated in 50 ohms).
- Dynamic Range: ± 0.5 volt.
- External Signal Level: Up to 1 V p-p may be safely applied to the SIGNAL OUT connector.
- Attenuator Accuracy: $\pm 3\%$.

Step Generator:

- Amplitude: approximately 0.25 V into 50 ohms (0.5 V into open circuit).
- Rise Time: Approximately 50 psec.
- Output Impedance: 50 ohms ± 1 ohm.
- Droop: Less than 1%.

Distance/Time Scale:

- Distance Scale (cm Line/cm Display) Accuracy: 5%.
- Polyethylene Line ($\epsilon = 2.25$): cm/cm to 2000 cm/cm.
- Air Line ($\epsilon = 1$): 300 cm/cm to 3000 cm/cm.
- Time Scale: 20 to 200 nsec/cm, $\pm 5\%$ accuracy.
- Magnification: $\times 1$ to $\times 200$ in 1, 2, 5 sequence.
- Accuracy of the basic sweep is maintained at all magnifier settings with the exception of time represented by the first 0.1 cm of the top of the step.
- Delay Control: 0 to 10 cm of unmagnified sweep, calibrated.
- Jitter: Less than 20 psec.

Power: Supplied by oscilloscope.

Weight: Net, 7 lbs (3.2 kg). Shipping, 11 lbs (5 kg).

Accessories Furnished: 2 GR elbows (HP Part No. 1250-0239). 1 GR to Type N Adapter (1250-0240), and 1 Type N to BNC Adapter (1250-0067).

Price: 1415A, \$1050.

Option 14: Long-line TDR for cables up to 1500 meters (0.62 mile). P7 phosphor recommended for Model 140A, no extra charge. Specifications same as for 1415A except as follows:

- System Rise Time: Less than 200 psec.
- Rep Rate: 30 kHz, nominal.
- Noise and Internal Pickup: $< 0.25\%$ of step.
- Droop: $< 2\%$.
- Time Scale: 20 nsec/cm to 1 μ sec/cm.
- Air Line: 300 cm/cm to 150 m/cm.
- Polyethylene: 200 cm/cm to 100 m/cm.
- Price: 1415A Option 14, \$1150.

TDR ACCESSORIES

RISE TIME CONVERTERS



Model 10452A through 10456A Rise Time Converters slow down the step from the 1415A in order to eliminate reflections caused by frequencies beyond the bandwidth of interest.

Specifications

- Rise Times: (10-90% points as measured in 150 ps rise time system.)
- 10452A: 0.5 nsec. 10453A: 1 nsec. 10454A: 2 nsec.
- 10455A: 5 nsec. 10456A: 10 nsec.
- Rise Time Accuracy: Better than $\pm 5\%$.
- Overshoot: Less than $\pm 3\%$.
- Output Impedance (dc): 50 ohms (accuracy determined by output impedance of generator).
- Output Mismatch: Less than $\pm 5\%$ reflection to output rise time.
- Allowable Input Voltage: Up to 50 volts, open circuit (from a 50-ohm source).
- Connectors: GR Type 874.
- Price: \$75 each.

75-OHM ADAPTERS



Adapters convert 1415A 50 ohm output to 75 ohm systems.

Model 10457A: Converts 50 ohm GR to 75 ohm Type N. Price \$35.

Model 10458A: Converts 50 ohm GR to 75 ohm Type F (CATV). Price \$25.

874A/B Susceptance Standard



The 874A is a TDR comparison standard for simple, rapid, direct-reading evaluation of reactive discontinuities.

Specifications

- Characteristic Impedance: 50 ohms ± 0.1 ohm.
- Capacitance Range: 0 to 1 pF.
- Inductance Range: 0 to 2 nH.
- Accuracy: Capacitance: ± 0.005 pF or $\pm 5\%$, whichever is greater, from 0 to 0.5 pF. Inductance: ± 0.013 nH or $\pm 5\%$, whichever is greater, from 0 to 1.3 nH.
- Line Length: 17.4 cm.
- Connectors: 874A, GR type 874; 874B, APC7.
- Price: 874A, \$275; 874B, \$325.

K60-1415A HUM FILTER



Power line interference can be reduced with the K60-1415A Hum Filter when used with Time Domain Reflectometers such as the HP Model 1415A. A front panel switch allows you to select either 60 Hz or 400 Hz filtering.

Specifications

- Hum Rejection:
 - In a 50 ohm Hum Source
 - 50 - 120 Hz: 40 db
 - 400 Hz: 35 db
- Introduced Reflection: Less than 5%.
- Step Distortion (Droop): Less than 3%.
- Power:
 - 115 - 230 volts AC
 - 50 - 400 Hz
 - 1 watt
- Price: \$175.00

CAMERA-PROBES-TESTMOBILES

Voltage Divider Probes



The high impedance input of these probes reduces loading of oscilloscopes on the circuit under test, and the probes provide attenuation for large signals. The probes may be quickly and accurately compensated for optimum step response.

Probe	Atten.	Bandwidth (0.5 dB)	Resist-ance (Meg-ohms)	Capaci-tance	Div. Accu-racy	Peak Input Volts	Approx. Over-all Rise Time	Approx. Price
10001A or C*	10:1	dc to 30 mc	10	20 pf	2%	600	5'	5 nsec \$30.00
10001B or D*	10:1	dc to 30 mc	10	20 pf	2%	600	10'	5 nsec 35.00
10002A or C*	50:1	dc to 30 mc	9	2.5 pf	3%	1000	5'	5 nsec 40.00
10002B or D*	50:1	dc to 30 mc	9	5 pf	3%	1000	10'	5 nsec 40.00
10003A or B*	10:1	dc to 40 mc	10	10 pf	2%	600	4'	3 nsec 30.00

* These probes have black identification boots; the others have red boots.

Straight-Through Probe



The 10025A is a thin, flexible probe with push-button pincer jaws to provide a straight-through connection to hard-to-get-at-test points. Price, \$15.

Probe Tips



10035A Probe Tip Kit, \$5

Provides maximum versatility when used with the voltage divider probe. The kit contains a pincer jaw, banana tip, pin tip, hook tip, and spring tip.

Testmobiles

The 1117B and 1119A Testmobiles provide convenient portable use of oscilloscopes and other equipment. The 1117B accepts rack mount units, making it a mobile test station. 1117B, \$185; 1119A, \$110.



1119A Testmobile



1117B Testmobile

Blank Plug-ins



Half-size, 10477A, price \$25. Full size, 10478A, price \$30.

Current Probe and Amplifier



1110A Probe and 1111A Amplifier permit direct measurement of current from 50 Hz to 20 MHz. Sensitivity is 1 ma/cm to 5 a/cm. 1110A (usable separately, 1700 Hz to 40 MHz), \$100. 1111A, \$160.

Adapters



10110A BNC to Banana Post Adapter, \$5

10111A Shielded Banana Plug to BNC Adapter, \$7

Viewing Hoods



10175A, \$15

10175B, \$15

Polarized Hood increases contrast and reduces glare for viewing dim traces under all ambient light conditions.

Hood with removable vinyl face mask ideal for viewing fast transients (non-polarized).

Camera



Model 197A Camera provides an accurate, convenient way of recording scope traces. The 197A has a black light for illuminating internal gratitudes, providing easy-to-read, three-shade photographs. 197A, \$540; 197A, Option 01 (without black light) \$490.

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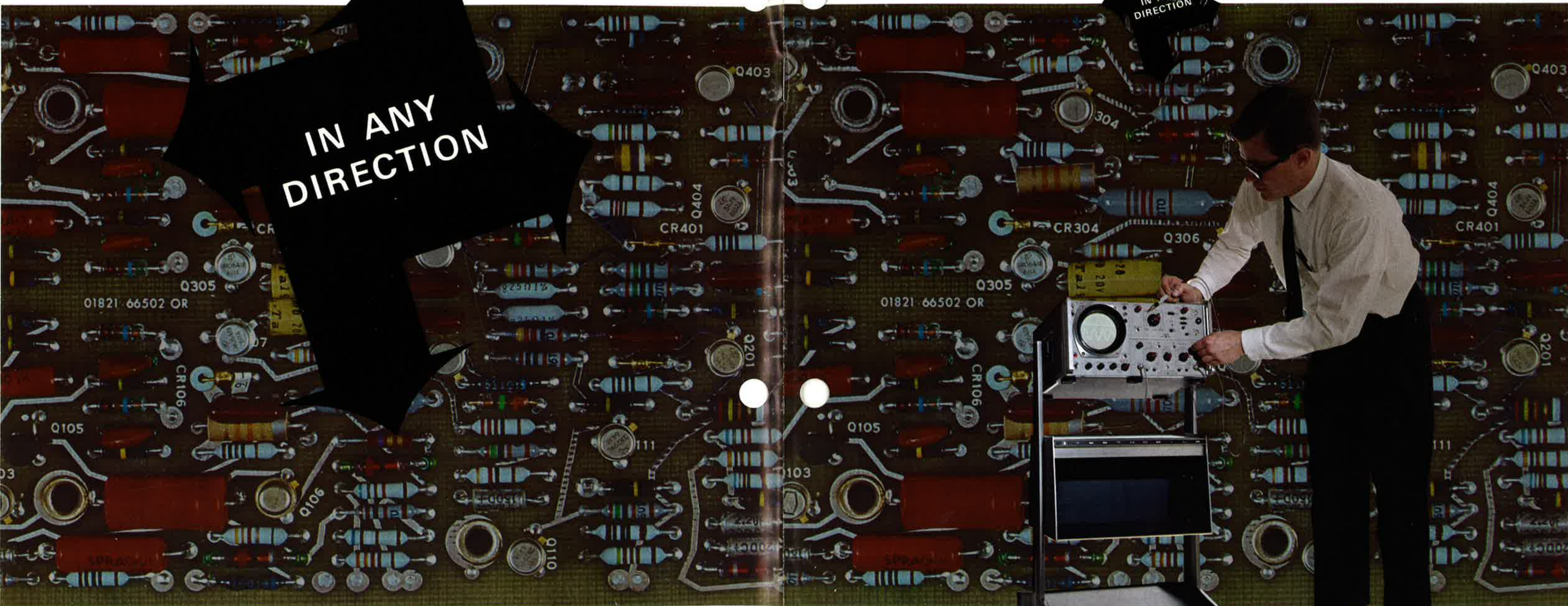
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